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"Normal" & "Ambiguous": How Undergraduate Engineering Students Describe Stress*

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Mental health of undergraduate engineering students is a growing concern. While some studies have measured undergraduate engineering student mental health and characterized stressors, more work is needed to understand how undergraduate engineering students describe and communicate about stress, including its relation to mental health. Our research sought to address the following research questions: (1) How do undergraduate engineering students describe stress and stressors? and (2) How do undergraduate engineering students describe the relationship between stress and mental health? We conducted and analyzed 30 semi-structured interviews with undergraduate engineering students at one institution in the United States. In interviews, we asked students about how they describe stress, including words they use to talk about stress, and how stress is related to mental health. We implemented a content analysis to analyze words students use to describe stress and a thematic analysis to analyze student descriptions of the relationships of stress and mental health. Despite stress being perceived as normal, students offered varying definitions of stress and ways to communicate about stress across three main categories: emotional, physical, and motivational. Student definitions and descriptions of mental health concepts such as stress and anxiety varied significantly, and were sometimes conflated, suggesting student descriptions, communication, and understanding regarding these topics may not be precise. Underlying these descriptions, however, was a consistent assumption that stress and other mental health issues were closely related, if not the same. The varying definitions of stress and common use of the term by engineering students may create ambiguity among students and between students and faculty. This normalization coupled with ambiguity of terms may preclude students from receiving needed support. Understanding how students describe and communicate about stress will be critical to developing proactive interventions that engage students to support their mental health.

Keywords: mental health; undergraduate; qualitative; thematic analysis; content analysis; word cloud

1. Introduction and Background

There is growing international concern about the mental health crisis in higher education, involving high rates of student mental health challenges [1–4]. This work, conducted in the United States, focuses on the experiences of engineering undergraduate students. Continuing studies in the United States indicate that both a growing number of college students and a proportion of college students higher than the baseline adult population are diagnosed with mental health disorders and that the severity of these diagnoses and use of university counseling services is also increasing [4–8]. Recent work has indicated that rates of mental health challenges are high in undergraduate engineering programs [9, 10]. Engineering programs have been described as environments of "suffering and shared hardship" [11, p. 12] that may create expectations of high stress as a norm. These high stress levels and normalization of stress may be particularly problematic for historically marginalized groups in engineering (e.g., women, Black Americans), who already face higher levels of stress and anxiety due to underrepresentation and microaggressions in engineering [12–14]. Normalization of high stress as necessary in engineering may also create cultural barriers to help-seeking for mental health challenges [15, 16].

While previous research has categorized stressors for undergraduate students [17], with some studies specifically focusing on stressors for undergraduate engineering students [18, 19], less work has been done to understand how students describe stress and how it relates to overall mental health. Specifically, there is a lack of research exploring what language undergraduate engineering students use to communicate about stress and how stress is related to other mental health concepts. To address this, we ask, (1) How do undergraduate engineering students describe stress? and (2) How do undergraduate engineering students describe the relationship between stress and mental health?

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We posit that a deeper understanding of how students describe stress, including understanding how they differentiate between stress and other mental health challenges, will be important in engaging with and identifying students who are at-risk and in identifying interventions to best support undergraduate engineers. We further propose that the cultural narratives of engineering of "suffering and shared hardship" [11, p. 12] coupled with the colloquial overuse of the word stress to describe a wide range of experiences, creates an environment where student experiences and needs may not be sufficiently identified and communicated, both by peers and educators. Towards the goal of increasing our understanding of the student experience of stress, here we describe an analysis of student descriptions of stress and how they understand stress as related to mental health, derived from interviews with 30 undergraduate engineering students. This research is part of a larger mixed methods study that seeks to understand undergraduate engineering students' perceptions of mental health in engineering culture. Our previous work has reported that undergraduate engineering students experience high levels of stress and students describe high stress as normal and expected in engineering programs [9, 15, 20]. The present research is part of the qualitative phase of the larger study, where we extend this work by analyzing participant interviews explicating how students describe stress. Our objective for the research is to enhance educators' understanding of the student perspective around stress to inform proactive supports for students.

2. Literature Review

2.1 Definitions of Stress

Stress is a common experience in everyday life. Despite this, many disparate definitions exist for stress, ranging from everyday colloquial use to clinical definitions and measures. Some definitions are broad, for example, the Center for Disease Control describes stress as "how our body responds to pressures or tension" [21]. The United States' National Institute of Mental Health explains: "Stress is the physical or mental response to an external cause, such as having a lot of homework or having an illness. A stressor may be a one-time or short-term occurrence, or it can happen repeatedly over a long time" [22]. Some definitions include physical outcomes of stress. For example, the National Cancer Institute [23] describes stress:

> "In medicine, the body's response to physical, mental, or emotional pressure. . . Long-term stress or high levels of stress may lead to mental and physical health problems."

Other definitions provide neither negative nor positive connotation. Often referred to as the "father" of stress research, Hans Selye defined stress as "the nonspecific response of the body to any demand"; his work concluded that stressful events can cause physical symptoms in both animals and people [24, p. 39, 25].

While Selye is often credited with bringing attention to the negative effects of stress, Selye also acknowledged that some stress can be positive, distinguishing between "eustress" and "distress" [26]. Researchers have since demonstrated that certain amounts of stress are needed for optimal performance; a "Goldilocks" scenario of not too little and not too much described by the Yerkes-Dodson law [27]. Despite this, the colloquial use of "stress", particularly for undergraduate students, has a negative connotation [15, 20]. Given the expectations of high stress and even glorification of high stress by students [15, 20], it is important to further our understanding of how students experience stress and how their beliefs about stress impact their behaviors (e.g., help-seeking) and interactions with faculty and peers.

2.2 Mental Health and Stress Among Undergraduate Engineers

Limited, but recently increasing research exists on the mental health and well-being (MHW) of engineering students. Reviews of this scarce body of research call for increased studies of the mental health of both undergraduate engineering students [28] and graduate engineering students [29]. A subset of this research concerns stress, which one review posits to be "one of the most prevalent MHW problems in engineering education today" [28, p. 1063]. Multidisciplinary research indicates that undergraduate engineering students across institutions in the United States consistently rate higher on indices of mental health and mental health awareness than undergraduate students in other academic disciplines at their same institutions [30, 31]. Specifically, engineering students experience higher rates of depression and burn-out, decreased rates of retention, and are more at risk of developing other more serious mental illnesses like post-traumatic stress and anxiety disorders than students in other disciplines [10, 32, 33]. Our previous work has indicated that engineering students experience high levels of stress, with nearly 30% reporting moderate to severe stress [9]. Concerningly, despite these high levels of stress, research has suggested that engineering students may be less likely to seek help or counseling services for mental health challenges compared to students in other academic fields [30, 34].

Research studying undergraduate engineering

culture may be key to revealing why these trends exist for undergraduate engineering students. Godfrey and Parker [11] investigated the cultural framework of engineering at an institution in New Zealand and determined that engineering students are inclined to value academic and emotional hardship as a necessity in their education, which may contribute to a normalization of stress, particularly academic stress. Academic demands are implicated in multiple studies as being a critical source of engineering student stress (e.g., [15, 35, 36]). Additional research has identified that the cultural acceptance and expectation of excessive hardship and high stress contributes to engineering students describing their undergraduate experience as unique [29, 37] while simultaneously feelings of shame due to experiencing failure can be deep and painful [38]. Unfortunately, these perspectives may support and even promote non-adaptive responses and coping mechanisms to stress such as skipping on necessities such as sleep, hygienic practices, and meals, and cutting back on investments in social relationships to create more time for academic work. Given the unique culture of engineering and the high levels of stress reported by engineering students, we believe an increased understanding of engineering students' experiences with stress, specifically how they describe and communicate about stress, will benefit efforts to engage with students and support mental health. Researchers of engineering students' mental health have made calls for cultures of wellness [39] that holistically consider and promote students' positive well-being and mental health [40] and support student thriving (e.g., [41]). We believe that identifying and dismantling cultures surrounding stress will support these goals.

3. Methods

The current study is a part of a larger project that has incorporated a sequential explanatory mixed-methods research design [42] with the goal of better understanding the role of undergraduate mental health in engineering programs. Quantitative data from a mental health measure were initially collected from a large sample of undergraduate engineering students at one institution in the United States [9]. In this manuscript, we focus on the qualitative phase of the project. We selected potential interview participants based on high or low engineering identity measures [43] on the quantitative survey to achieve maximal variation of student experiences.

Our research questions address undergraduate engineering students' understanding of and experiences with stress and with broader mental health issues. Specifically, we investigated how these concepts were defined and described by students. Investigations of these concepts required searching for trends across participants' definitions and experiences. Our overall research questions are: (1) How do undergraduate engineering students describe their understanding of and experiences with stress in the context with broader mental health issues? and (2) How undergraduate engineering students define stress in the educational context experienced by engineering students? All materials and procedures were approved by the university's Institutional Review Board before data collection began.

3.1 Participants

Participants included 30 undergraduate students in the college of engineering of a large, public R1 university in the United States, selected from a pool of 1,190 respondents who responded to a survey on engineering stress and identity in Fall 2017 [9]. We identified 150 of the 1,190 student respondents that had either high or low levels of engineering identity (defined by upper and lower quartiles measured on the survey by major) [43] and contacted them by email and offered a $30 Amazon gift card. Of the 150 contacted, 38 respondents were willing to participate (approximately 25% response rate); however, eight could not participate due to scheduling conflicts, resulting in 30 participants. Of the 30 interview participants, 18 had a high engineering identity and 12 had a low engineering identity score. Of the 30 participants, 13 identified as White, 4 as Asian, 13 did not specify a race or ethnicity. Female students were overrepresented in our sample, with 20 participants self-identifying as female, nine as male, and one participant choosing not to specify a gender. Participants had completed nearly two years of study or greater in the college of engineering at the focal institution at the time of the interviews. Participants were asked at the start of the interview to suggest a pseudonym, and if they declined to suggest a pseudonym, one was selected by the research team (Table 1).

3.2 Data Collection

All 30 interviews were conducted in the Spring 2019 semester and took place within a private interview room with only the participant and one of two interviewers from the research team. Participants were asked if they had any questions about the interview or consent form before beginning the interview. Participants were also informed during the consent process that they could terminate the interview at any point. At the conclusion of the interview, participants were presented with a list of campus resources, including the counseling center.

Table 1. Participants: Engineering Department and Pseudonym

Department	Pseudonym
Bioengineering	Olivia
	Katie
	Ashley
	Talia
	Georgina
	Cecilia
	Chandler
	Caleb
	Bradley
Civil & Environmental Engineering	Jasmine
	Lori
	Molly
	Grace
	Victoria
Computer Science	Rocco
	Josh
	Becca
Material Science	Ralph
	Joe
	Emily
	Amy
Mechanical Engineering	Nathan
	Chris
	Richard
Physics	Chelsea
	Allison
	Ozul
Additional Majors	Abby
	Anna
	Nas

Note. Additional Majors represents smaller departments of engineering that were collapsed to protect the identity of those in this study.

All interviews were conducted face-to-face, audio recorded, transcribed verbatim, and analyzed using MAXQDA 2020 [44]. The average length of the interviews was 39.1 minutes, ranging from 21 minutes to 64 minutes. Interviewers completed field notes after each interview to summarize the interview and to document observations.

3.3 Interview Protocol

The semi-structured interview protocol was developed from the results of the quantitative survey from Fall 2017 [9] and reviewed by a panel of experts. The semi-structured interview protocol was designed to last 30 to 60 minutes and included 22 structured questions; that full protocol has also been previously published [15]. For the purpose of this study, we analyzed only responses to the questions about stress. This section of the protocol included questions asking participants to describe what stress means to them and what words they use to talk about stress: "When you hear the word stress, what does it mean to you? How do you define stress?" and "Sometimes we use other words to indicate feelings of stress. What other words do you use to describe or talk about stress?" An additional question asked students about how stress relates to other mental health concepts and their experience of stress: "In your opinion, is stress different from anxiety or depression?" Results from additional items asked about during interviews are presented elsewhere [15].

3.4 Data Analysis

To analyze the interview data, we leveraged thematic analysis [45] supported by the creation of word clouds as visual tools. Thematic analysis is appropriate for developing a descriptive understanding of phenomena using qualitative data [46] without requiring direct connections to theoretical perspectives [47, 48]. Word clouds increase the comprehensibility of qualitative data while emphasizing the prevalence of certain ideas and are particularly effective for demonstrating quantitative patterns in how participants qualitatively describe intent, association, or judgements of ideas [49–51].

Experiential word clouds. Student descriptions and definitions of stress were analyzed for overarching categories. The results suggested experiences of stress were affecting three major areas of health: emotional, physiological/physical, and motivational. To further explore how students describe the emotional, physiological, and motivational experiences of stress, we constructed a word cloud for each of the three descriptor categories or cases. Word clouds are a type of text-based visualization that highlights the prominence of frequently occurring words or phrases [52]. We removed linking words and prepositions (e.g., "and", "the", "however") and non-frequent words from the text so that the visualization represents re-occurring words of importance. These visualizations can then be used to highlight points of interest and differences within text-based data and provide additional support to analytic interpretations [49, 50] and have been used in qualitative STEM education research (e.g., [53]).

To construct the word clouds we completed the following steps: (1) text from all 30 interviews six-question responses was compiled into a single document, (2) all terms or phrases not directly pertaining to one of the three themes were removed, (3) common terms (e.g., worry and worried) were combined, (4) the text was separated by the three themes, and (5) word clouds were constructed using the WordItOut software [54]. The following criteria were required for the text to be included in the word

cloud: word/phrase must appear at least twice within one of the six stress interview questions of any transcript and not be for sentence structure (e.g., however, there, the, etc.). The most commonly stated emotions, physiological responses, or motivations appeared as larger words, and those less frequently cited appeared as smaller words.

Thematic Analysis. To conduct the thematic analysis, two authors reviewed a subset of transcripts following a multi-stage coding process involving open, axial, and selective coding [55] to produce a full corpus of coded data. We describe each of the phases and the data produced at that stage in the sub sections below.

Open coding. Open coding was conducted by two of the researchers on the entire transcript for 20 of the transcribed interviews, with each researcher analyzing 10 unique interviews. Conversations between the two coders and in meetings with the larger research team resulted in dividing the interviews by topic and creating separate codebooks for each. The second author then revised the codebook and developed a preliminary coding scheme consisting of 40 codes describing types of stressors and responses to stress. Examples of categories of stressors included "academic", "time", and "social," and examples of responses to stress included "defeated/drained", "frustration/anger/annoyance", and "anxiety." The two coders applied the 40-code scheme created during the collaborative phase of open coding to the 10 previously coded transcripts and 10 non-coded transcripts.

Axial coding. During the first round of axial coding the presence (1) or absence (0) of each code was determined as well as the frequency of each emotion (e.g., anxiety), motivation (e.g., self-efficacy), and physiological (e.g., tired) descriptor. Agreement between the coders was then determined and revealed less than 70% agreement, thus the coders adopted a negotiated agreement approach to resolve discrepancies [56]. The coders then met to collaboratively discuss differences and further refine the coding scheme. The refined and final coding scheme included 25 codes. Examples of those refined codes included "Stress-Neg Emote: Frustration", "Stress-Neg Physical: Lack of Sleep," and "Stress-Neg Motivation: Low Control."

Selective coding. In the final, selective coding phase, the second and third authors then recoded the data and discussed disagreements. While most codes did have greater than 80% agreement between the two coders, differences were still discussed collaboratively until 100% agreement was met across all codes. At this stage, the team collaboratively determined that two major themes could be generated to summarize the codes. First, some codes comprised descriptors (emotional, physiological, and motivational) of stress and stressful experiences. Second, some codes described how students defined or conceptualized stress and relationships between stress and mental health.

3.5 Positionality

We acknowledge our roles as instruments in qualitative methods described in this study and provide our positionality as researchers to reflect on how our training, prior work, identities, and experiences influence the research design and analysis [57–59]. The research team purposefully reflected on and discussed impact of team members' positionality during the analysis and writing stages of the project [60]. The interdisciplinary research team included, at the time of data collection and analysis, a faculty member with engineering research experience, a faculty member with engineering and engineering education research experience, doctoral students with engineering and educational psychology research experience, and an undergraduate engineering student.

The research team shares interest in mental health, workplace culture, and equity in engineering. One team member was an engineering student at the focal institution at the time of the study. One team member currently has taught as an engineering instructor, including at institution of study. This teaching experience, coupled with many years of discussing mental health concerns with students, prompted the researcher's interest and advocacy in student mental health and interest in conducting the study. The mixture of team members with and without lived experiences as engineering students was vital to the success of the study: experiences of the team members with lived experiences as engineers provided empathy and understanding during interview collection and analysis; while the team members with education student experiences were able to check results and discussion for generalizability beyond engineering student experiences and reduce the potential for bias in discourse about the results.

3.6 Quality

To ensure research quality, we adhered to quality procedures for qualitative research at all stages of the research process, including research design, data collection, and data analysis [61]. The research design and instruments were periodically reviewed by an external advisory board for face validity. The interview protocol was piloted with participants outside the sample to ensure clarity. We implemented constant comparative method for procedural validity [62], frequent research team meetings to

compare, discuss and revise codes for communicative validity [58], and detailed fieldnote and memo writing and use of standard guidelines for process reliability [63]. Our interdisciplinary research team frequently discussed subjectivity [64] and discussed the perspectives we were bringing to the analysis from our roles as engineering instructors, engineering undergraduates, and educational psychology graduate students (refer to Positionality).

4. Results

Undergraduate engineering students interviewed in this exploratory study offered insight into the language they use to describe stress. While most students shared that stress was normal, several students shared that they perceived ambiguity around the term "stress". For example, a student named Chelsea said,

> "I think it's a very overused word. Um, but I definitely do say that like I'm stressed very often. Um, I think it's stress, uh, I think to me it kind of feels like [stress]. It's gotten to the point where I don't even really know what saying [being stressed] means anymore. It's like sort of a description of say like you have a lot of work to do – I don't have time for anything else. But in terms of like how I feel, I don't really know like if there is a specific emotion that I feel or say like when I say that I'm stressed."

Despite most engineering students in our study describing stress as normal and ubiquitous, articulating the process and impact of stress may be challenging for students. When asked what the term "stress" meant to him, Richard shared,

> "Um. . . nausea (laughs). And... late nights (pause) and . . . I think also normal. I think stress is normal. Um, and. . . I think ambiguous, 'cause it can be a good thing to be stressed or it can be a bad thing."

While many students acknowledged some positive outcomes for stress, the majority of emotional, physical, and motivational descriptors students used to describe stress (Figs. 1–3) were negative. While literature on stress acknowledges both positive and negative implications of stress (e.g., [27]), reconciling both negative and positive implications of stress was a main point of the ambiguity many students described. Further, some students may not identify differences between stress and other mental health challenges like anxiety and depression. For example, the most common word to describe emotions of stress used by students is anxiety (Fig. 1). When asked what words they used to indicate feelings of stress, Nas shared, "Overwhelmed. Anxiety . . . Defeated a little bit. I feel like those are the only ones I really use." As a result, students may not differentiate between stress and anxiety, which may impact their help-seeking behaviors.

4.1 Descriptors of Stress

Three categories of descriptors emerged as themes describing participants' descriptions of stress: emotional, physiological/physical, and motivational. These three categories were described in both positive and negative lights, but an overwhelming portion of students' definitions emphasized solely negative perspectives. This largely one-sided view of stress as negative suggests that students' experiences with stress thus far have been predominately negative or that the positive experiences from stress are not often perceived as what students typically define as stress and thus were not reported in response to us asking about stress. Furthermore, the findings from our analyses revealed that many emotions, physiological responses, and motivational effects are commonly shared among many undergraduate engineers. In the following sub-sections, we describe in detail each of the categories.

4.2 Emotional Descriptors

Of the three categories, at least one emotion or unique emotional term/phrase was reported by 100% of the participants and on average three different emotions were reported to describe stress. Fig. 1 visualizes the different terms to describe their stress-based emotions, and noticeably the terms "anxiety" and "overwhelmed" were central to how students were describing the emotions of stress. Two codes represent a sense of overwhelm: "overwhelmed," which captured words and phrases like "overwhelmed" or "feeling strained", and "busy", in which the engineering workload was specifically implicated, such as feeling "swamped by/from work". For example, two students described their emotional associations with stress as, "Like, anxious or frustrated. Disappointed" and "Overwhelmed. Anxiety. Defeated a little bit." Four emotional words or phrases were most frequently reported by students: Anxiety (57%), Overwhelmed (47%), Worry (37%), and Anger/Frustration (33%).

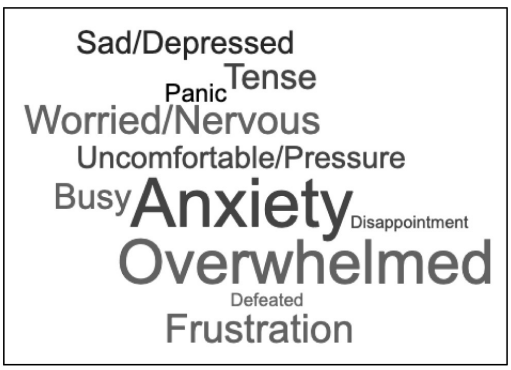

Fig. 1. Students' Emotional Associations with Stress.

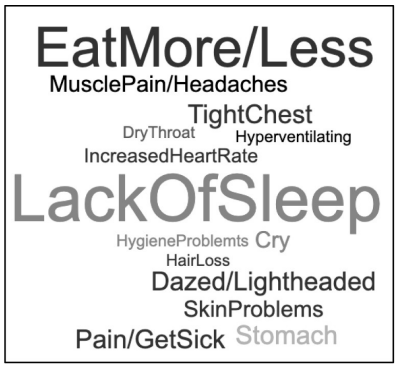

Fig. 2. Students' Physiological/Physical Associations with Stress.

Interestingly, all the most highly reported emotions represented those that are high arousal and negative valence. No positive emotions, high or low arousal, were reported as associated with stress. Only three low arousal [65] and negative valence emotions were reported: Defeated/Drained (10%), Disappointed (7%), and Sad/Unhappy (20%). The larger portion of negative emotions being high arousal is consistent and reflective of emotion literature that suggests stressors trigger high arousal emotions such as fear or curiosity [66]. The smaller portion of low arousal emotions reported may suggest less people are likely to experience low arousal from stress but given students' concern for effects of stress on depression, concern should still be given to the role of low and high arousal emotions in stress.

4.3 Physiological and Physical Descriptors

The interview protocol specifically asked students to describe physiological/physical responses to stress, which were reported by 93% of the participants. On average, two different physiological responses were reported per person. Fig. 2 represents the different terms used by students to describe their stress-based physiological responses when responding to the following interview question: "Have you or others noticed physical signs of your stress?" Noticeably, the terms "Lack of Sleep" (57%) and "Eat More/Less" (47%) were central to students' experience. Emily described their physical associations with stress as,

> "Your breath getting shallow, and you kind of feel like your heart is beating a little fast even though you're just kind of sitting at your desk, and you're not actually like exerting yourself. You kind of feel like your heart is beating a little faster. There's a feeling of like a, when you're nervous, and you get like a tightness kind of in the pit of your stomach."

Students' emphasis on maladaptive behaviors (i.e., lack of sleep or eating) and more serious physiological responses (i.e., lightheaded, hyperventilation, and tight chest) suggests that the engineering students in this study are experiencing, and potentially expected to experience, higher thresholds of or physiological response to stress that would normally be attributed to people experiencing depression and anxiety – not stress [67].

4.4 Motivational Descriptors

Lastly, motivational features were also described as a part of students' definitions of stress. Unlike physical or emotional responses to stress, the interviewers did not explicitly request motivational descriptions of stress in the interviews, and this theme is an emergent result. Fig. 3 represents the different terms used by students to describe their stress-based motivational responses. Effort and beliefs about one's abilities to succeed in engineering (coded as self-efficacy) were central to students' descriptions of stress. Unlike emotional and physiological associations, motivational associations were reported as both positive and negative. Specifically, negative features of motivation such as loss of self-efficacy, focus, effort/drive, and control regarding stress were coded 30 times, and positive descriptions of motivational associations with stress such as increase in focus or self-efficacy were coded 13 times. For example, a negative view of stress on motivation was described by a student who shared, "[it's the] feeling of kind of not living up to expectations," while a positive description was described by a student as "a relaxed state, I kind of thrive on stress . . . [stress] keeps me

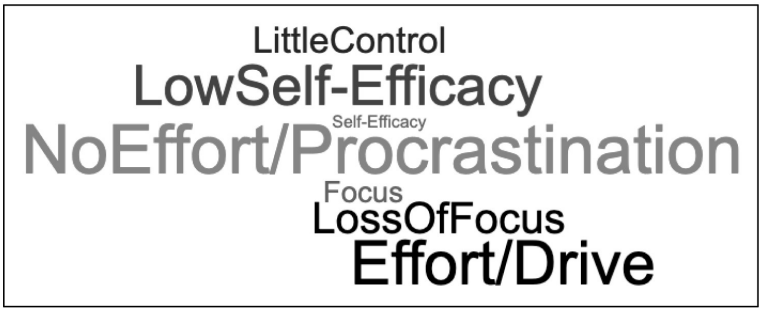

Fig. 3. Students' Motivational Associations with Stress.

motivated.'' These statements reflect that some students experience or only perceive stress as harming motivation, impacting self-efficacy, effort, and focus, while other students view stress as positively impacting their motivation.

There were also students, though fewer, who recognized stress as both beneficial and harmful to motivation. For example, Georgina stated,

> ''I think it's something that's always present, not just because of school, but in real life, or everyday life, it's something that's gonna be there. I don't think of it as a negative thing, because I actually enjoy not being stressed, [but] the presence of stress because it pushes me to do better and it kind of motivates me. But, once it becomes an extreme, it reaches an extreme level then it can definitely eat you away and makes you not want to do anything, and just keep procrastinating.''

This student provides a more balanced understanding of how stress is inevitable throughout life and that stress an differentially impact motivation over time. Considering student descriptions include both positive and negatives effects of stress of motivation, it may be beneficial to further examine students' perceptions of motivation and stress to gain a better understanding of how engineering students appraise stress.

4.5 Differentiating Stress from Mental Health Concepts

To understand how participants conceptualized and described their experiences with stress, we employed thematic analysis techniques. We started with how students differentiated stress from, and related stress to, other mental health concepts (e.g., anxiety, depression). Two themes related to how students compare stress to other mental health concepts emerged: the timespan (i.e., acute or chronic) and magnitude. In Table 2 below we include four quotes that captured students' understanding of stress being short-term, something that comes and goes, or is rather acute compared to how

Table 2. Example Quotes of Students' Perceived Differences Among Mental Health Concepts*

Differentiating Timespan of Stress from Mental Health Concepts	Differentiating Magnitude of Stress from Mental Health Concepts	Relationship Between Stress and Mental Health Concepts
I think stress is something that often happens in short increments. But after time, when those sort of events have passed on, that stress is no longer really seen, but it could be transferred to some other form. (Chandler)	Anxiety and depression have, there's two different types, there's the one that people use it casually and then there's also the clinical anxiety, clinical depression. And people throw around the terms a lot. And so, I think that there should be two different terms. Like, there should just be like the regular anxiety and regular depression and then like, clinical. (Talia)	They all correlate into one another, um, thing anxiety or like create so-stress for me. But it also can help let go into depression. Like, I don't know if what I'm trying to say, but like kind of lead into depression I would say. (Lori)
I find that stress ebbs and flows. It comes and goes depending on the time of the year, or you know, just what's going on around you. And I think that something like anxiety or depression will be, you know, not, it's more like intrinsic, I think. (Emily)	Stress is more of just not being able to get work done, but I feel like anxiety and depression goes deeper. And I think it's more of a mental health issue. (Becca)	Anxiety often is a component of stress because when we are stressed, I think we often have that anxiety of, ''How am I going to be able to just get these tasks done? How am I going to be able to accomplish them effectively?'' So, I think stress and anxiety go, often hand in hand, but stress and depression are on two different opposites in my mind. (Chandler)
I think stress is more, I guess more temporary. Like depression is like, like you can't just like, you know, get depression like, or like, something that's a long-term thing. I feel like, it's similar to anxiety. But I feel like I know I experienced stress. And it usually like. On my experience, they're like a couple of days before the, before an exam. (Rocco)	Stress is like I said, just operating at maximum capacity, physically or mentally versus like, anxiety and depression are like actual disorders that, in a sense are like how people handle stress or stressors. (Joe)	I feel like feeling depressed could be connected, but how I perceive it is feeling depressed is not having the motivation, or, just feeling helpless. Not necessarily because of stress, but I think it could also be from any other reasons, uh, mostly, like, psychological. (Georgina)
I'd say like stress is more of a . . . is like a fleeting feeling. It can come and go while anxiety and depression they kind of hang over you for a much longer period of time. Like maybe if you were stressed for like, I don't know, like a certain timeframe that was longer than normal, that would start putting it into one of those other categories. (Caleb)	I feel like depression what is mostly out of people's control. It's like a mental issue or imbalance in your head, from like, I don't know, some type of pheromones, or something. Something with your brain scans. (Anna)	So, stress is like the first level someone gets when something challenging like I said before, something challenging is going to happen to them or they are trying to do something challenging. Anxiety is the next step when they are worried about the result or if they'll do well in that sort of environment and depression comes later, which is like an aftermath. So, it's like the past, present and the future of a challenging task. (Ozul)

* Quotes are not transcribed verbatim in this table, e.g., filler sounds like ''um'', ''uh'', stammering, repeated words, and other verbalizations have been edited for clarity.

people may experience anxiety or depression. For example, participants Chandler and Rocco both mention stress may be triggered by academic deadlines such as an exam, but once that event has past the stress is alleviated by the external trigger (i.e., the exam) being removed. Anxiety and depression, however, are described as experienced for longer periods of time, and may not always be triggered by an external event but may rather reflect an internal or mental health challenge as described by Emily. Caleb further elaborates on this idea of chronic stress and makes a connection to the relationship between stress, anxiety, and depression by highlighting that if students remain stressed chronically, they may be at risk of developing anxiety or depression.

In addition to timespan, students also described stress as differing in magnitude or seriousness compared to anxiety and depression. Specifically, Joe, Anna, and Becca comment that anxiety and depression are "actual" mental health disorders or something internal that goes beyond not being able to complete tasks or meet external deadlines. The notion of internalization towards depression again appeared similar to how it was reflected in Emily's quote, which suggests that stress is a more universal, normalized, and externally accepted (i.e., a social norm) process as opposed to depression. Talia's comment also raises issues around magnitude and how students often conflate the terms stress, anxiety, and depression, because they do not have other language available to describe the variations in which stress, anxiety, and depression can be experienced. Interestingly, Lori and Chandler also highlighted that anxiety and stress are two words that are used or understood interchangeably while most students differentiate depression from other mental health concepts. This interchangeability and ambiguity of language around mental health that is perceived by students may be furthering confusion around mental health concepts and might interfere with counseling messages.

In addition to timespan and magnitude, stress was also highlighted to directly relate to anxiety and depression. Similar to Caleb's point that chronic stress can have effects on mental health such as anxiety and depression, Ozul and Lori also described depression as being the aftermath or product of stress and anxiety. Georgina and Chandler, however, viewed depression as a concept that functions more independent from stress and anxiety. The differences among these students' conceptualizations of stress could reflect how they have previously experienced stress. This could include the coping or self-regulation strategies they use, if any at all, and if they have ever had mental health challenges. As described by Ozul, mental health changes in stages and mental health challenges like depression can be the aftermath of stress and anxiety.

4.6 Relationships Between Stress and Mental Health

Once we had a foundational understanding of how students differentiate and associate stress with anxiety and depression, we then further examined specifically how students' perceived stress was affecting their motivation, anxiety, and depression. Example quotes are provided below in Table 3. Students reported that stress has positive and negative effects on their motivation, but only negative effects on anxiety and depression. Allison, Bradley, and Jasmine all consider stress to be a motivator that increases their effort. Interestingly, both Allison and Bradley also perceive stress as an essential for quality work and success as engineering students which implicitly reflects this notion of stress as a "normal" part of being an engineering student. Richard's statement was similar to Jasmine's in that stress helps his productivity, but he also echoed what many of the other students felt – that stress negatively affects motivation. Both Talia and Georgina further Richard's point by highlighting there is a threshold to stress and once students' reach a tipping point, they become overwhelmed and unmotivated. Talia, Sicilia, and Josh also highlight behaviors such as procrastination and not eating that are caused by stress. Interestingly, Sicilia also reflected on this notion of procrastination but highlighted that these problematic behaviors are reflective on engineering norms or culture.

In addition to perceived effects on amotivation, stress was viewed as also having negative implications for anxiety and depression. Ashley, Talia, and Allision all described stress as capable of leading to diminished mental health through worsening anxiety and depression, which is similar to Lori and Chandler's notion that stress, anxiety, and depression are co-created through each other. Jasmine's quote about depression going beyond stress and anxiety, however, reiterates that there are nuanced understandings about stress, anxiety, and depression and how they are related. Ashley, one of the few interviewees who explicitly identified themselves as struggling with anxiety or depression, agreed stress can lead to anxiety or depression, but also stated she can tell the difference between when she is experiencing stress or anxiety. Students like Ashley raise the question of whether clinical experiences with mental health (e.g., formal diagnoses or therapy) can help students differentiate between mental health concepts such as stress, anxiety, and depression in both language and experience.

Table 3. Example Quotes of how Students Perceived the Effects of Stress on Mental Health*

Positive Effects on Motivation	Negative Effects on Motivation	Negative Effects on Anxiety/Depression
I kind of, I don't know, I kind of thrive on stress. Not in a bad way. But, it kind of keeps me motivated and keeps me, like, moving forward. (Jasmine)	And so, there's like a level that like, okay I'm always stressed, so I should be able to just deal with it, right? Like, you're used to it. But then there's a point where I become overwhelmed and I am like, unable to like, oh I don't want to get lunch today because I'm feeling overwhelmed by all my stress. (Talia)	Stress leads to anxiety at least. I don't know, I have anxiety so like, I guess I could tell the difference but like stress is more of like a trigger than something that's like different necessarily. Like, stress leads to anxiety or depression. (Ashley)
Stress can be positive or negative. Like, sometimes stress can... You need it to be more productive and sometimes it's... you know, not necessarily a good thing (Richard)	I've noticed in my department a lot of, a disproportionate amount of procrastination like consistently across the board, um, and I wonder if we all like didn't quite learn to be good students in high school. Cause we were smart enough to get away with it and now we know we can, like, technically get things done at the last minute. It's just going to be like very, very stressful. (Sicilia)	I think that stress can cause your anxiety to be worse. And it can also cause depression to be worse. But I also think that anxiety and depression can cause you more stress. (Talia)
I feel like stress is just something I live with, and something I try, try with, or try on honestly, because you know if I'm not under that complete stress and just in a boiler maker I, I cannot do my work. So, I think stress is sort of a positive. Now it has become like a positive thing, because I need to be stressed about the work I do, about the quality I perceive and everything. (Bradley)	When I have anxiety or even depression, it's when I feel like, I have no ability to do a specific thing. For example, to get a specific job at a company. That not only stresses me out, but that causes me anxiety. (Josh)	I would relate stress more to anxiety than depression, but I feel like they're all kind of related, and if you have one you can kind of get the other. (Allison)
I need a little baseline of stress all the time to keep me going, when other people don't. But I feel like that almost helps you succeed in engineering classes and you kind of need that sometimes. (Allison)	I actually enjoy, not being stressed, the presence of stress because it pushes me to do better and it kind of motivates me. But, once it becomes an extreme, it reaches an extreme level then it can definitely eat you away and makes you not want to do anything and just keep procrastinat[ing]. (Georgina)	I think depression also it goes beyond those two. To me it seems like the most different of those, stress and anxiety might cause depression. (Jasmine)

* Quotes are not transcribed verbatim in this table, e.g., filler sounds like "um", "uh", stammering, repeated words, and other verbalizations have been edited for clarity.

5. Discussion

Bell Hooks wrote "If I do not speak in a language that can be understood, there is little possibility of dialogue" [68, p. 78]. According to hooks, to have dialogue we must first understand each other's language. Our study focused on how undergraduate engineering students describe stress and its relationship to mental health. We posit that a first step towards identifying solutions to the mental health crisis in undergraduate programs is the ability to initiate meaningful dialogue and understand the language used by students. Our study highlights the importance of language [69], specifically for student-student interactions, student-faculty interactions, campus initiatives to support student mental health, training for faculty working with students, and student advocacy training to identify peers at risk.

While engineering culture is an important part of the student experience, the relationship of engineering culture and student mental health, particularly around norms of stress, is understudied. Engineering culture has been described as unique compared to other disciplines [11]. One element of engineering culture described by Godfrey and Parker was the cultural ideals of hardness [11]. Our previous work found that engineering students not only reported high levels of stress, but that some associated diminished mental health with studying engineering [15, 20]. The notion that stress is a constant and even necessary or expected experience for engineering students may also contribute to different language usage about stress. Additionally, stress may be perceived differently by students of different sociocultural backgrounds, with more complicated relationships emerging at the intersection of multiple backgrounds. The idea that stress is normal and expected in engineering may further impact engineering student help-seeking strategies for mental health challenges. For these reasons it is important to understand how students perceive stress and what language students use to describe their experiences with stress. Understanding how engineering students conceptualize and describe stress will be critical to developing proactive interventions,

faculty training, and educational resources to support student mental health.

5.1 Implications for Higher Education

Knowledge and beliefs of mental health issues and disorders have been associated with the likelihood of student help-seeking [16, 70]. Our findings suggest that students describe stress as both normal and ambiguous and describe stress with emotional, physical, and motivational associations. Further, some students combine stress with other mental health concepts such as anxiety. These results have several implications for higher education. Our finding that students report high levels of stress as normal in undergraduate engineering programs is in agreement with our previous work [15, 20] and emphasizes the importance of understanding student perceptions and experiences in engineering related to stress and mental health.

Understanding student language used to describe stress will be important to identifying at risk students and implementing proactive interventions to encourage students to seek help for mental health challenges and to identify and advocate for at-risk peers. For example, students in our study frequently used, and described their peers as using, extreme language to describe their experiences. Caleb elaborated on this, saying,

> "I make jokes about like [stress], ah man like, I hate my life, this is awful. And then like while it's obviously a joke, there's also a kernel of truth, where it's like, oh my god, I'm super overwhelmed and I don't know what to do and I like want help with it."

The normalization of such language to indicate that a student is "just stressed" may exacerbate perceptions of high stress being normal or necessary for engineering as well as prevent students from identifying when peers are at risk and in need of help. Simply, if self-deprecating language becomes the norm of the culture, students are less likely to notice the problematic undertones in their peers' language. While previous work has demonstrated the benefits of cognitive, behavioral, and mindfulness-based intervention methods can be beneficial for students experiencing significant stress [71], research has shown that students from different social identities may be more or less likely to seek help [72–74]. Further, previous work has shown that engineering students with mental health challenges were less likely to seek treatment compared to students in other academic disciplines [30]. These findings suggest that greater attention is needed for undergraduate engineering student mental health, including the design of interventions and educational resources to help students identify and manage unhealthy levels of stress and to promote wellness in engineering education.

5.2 Limitations and Future Work

The study is limited to interviews with 30 students at a single institution and at a single time, which may limit the transferability of results. Since the participants in this study had completed varying amounts of their degree programs, our study does not capture the influences on student conceptualizations of stress and how their mental models and language used to describe stress may change over time with different experiences and social interactions. Lastly, our interview sample predominately included White women, which is not representative of enrollment in engineering programs nationally, which is predominately Asian and White men [75]. Research suggests that students of color and women face additional interpersonal (e.g., sense of belonging) and intrapersonal (e.g., lower self-efficacy) barriers that increase stress [76]. Thus, more research is needed to further explore gender and racial differences of experiences and conceptualizations of stress in engineering. While we believe that our findings are beneficial to educators in understanding how students communicate about stress, future work that examines the generalizability of the findings across additional contexts and student groups will contribute to our understanding of how students communicate about stress in engineering.

6. Conclusion

Here we describe an exploratory investigation of how engineering students experience stress and the language students use to describe stress. Overall, the results of study suggest that while engineering students view stress as a very normal experience, it is one that can be hard to describe, particularly for when stress is positive or negative and how stress differs and is related to anxiety and depression. Our participants defined stress in inconsistent ways: sometimes attributing stress to be part of anxiety or depression and sometimes attributing stress to worsen these, and sometimes describing other mental health phenomena as being components of or causing stress. Participants described both positive and negative effects to motivation as consequences with stress, while only associating stress with negative emotions and negative physiological responses. Future work that explores how students interact with each other and faculty, and how understandings of stress impact on help-seeking behavior will be important areas of inquiry to understand the student experience with stress in engineering and to develop proactive interventions to support student mental health.

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