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Dignity and well-being: Narratives of modifying the culture of engineering education to improve mental health among underrepresented STEM students

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Abstract

Previous quantitative research indicates that engineering students have "high rates of mental health struggles" (Danowitz and Beddoes, 2018, 2020, 2022a; Jensen and Cross, 2021; quoted in Beddoes and Danowitz, 2022b). However, until recently, research had not provided significant insight into why. Building on Seron and colleagues' research on how professional socialization affects women in engineering (2016; 2018), the three participants in this study explored their own experience of socialization into the culture of engineering during their education. This study used a culturally responsive and creative inquiry framework and qualitative research methods of conversational interviews, journals, and student-generated creative content, from which emerged the lived-experience narratives of female undergraduate STEM students with multiple underrepresented identities. Findings of this study show that underrepresented students exert hidden efforts that the current engineering meritocracy does not know of, value, account for, or understand. This culture manifests itself as a lack of time and flexibility to rest and maintain control over one's life and wellbeing. From the perspective of students with embodied differences, like physical and learning disabilities, this conception of rigor dehumanizes and removes their dignity, which can exacerbate mental health issues that many neurodivergent students already struggle with. Importantly, the participants' narratives show how they actively resisted the culture and developed practices of self-care.

Introduction

Research indicates that underrepresented students who participate in engineering education, like women, students of color, LBGTQIA+ students, and students with disabilities, may experience the campus and classroom environments as alienating and hostile, which can cause feelings of disorientation and uncertainty and affect their mental well-being (Allen, 2017; Cech & Waidzunas, 2011; Godfrey, 2007; Harper, 2010; Haverkamp et al., 2019; Kimmerer, 2013; Lee, 2020; Liptow et al., 2016; Lord & Camacho, 2013; Rice & Alfred, 2014; Riley, 2008, 2013; Seron et al., 2015, 2018; Slaton, 2013; Stonyer, 2002; Tate & Linn, 2005). Further, the culture of engineering education has been identified as a barrier to increasing the participation of underrepresented engineering students (Cech, 2014; Seron et al., 2018). To this end, the purpose of this empirical qualitative study was to better understand how students with underrepresented identities experience the culture of engineering during their education.

In this paper, we share the findings from this culturally responsive and creative inquiry to elevate the student participants' own voices and narratives of their experiences to illuminate how they experience the culture of engineering. Importantly, the participants articulated how the culture affected their mental health. The three female undergraduate engineering student participants each hold a variety of underrepresented identities, such as identifying as first-generation and low income while also having learning and physical disabilities. Furthermore, the findings focus on how these students adapted their expectations and behaviors to resist the pressures of the weed-out culture of engineering toward self-care and mental well-being and how they were working to create a new culture of community and caring. The participants chose to share their stories of their own struggles to show the differences that some students bring to their education. Their purpose was to make these differences visible to the campus and engineering education community so that those who do not share these experiences at least are aware of and understand them better.

The findings from the study are particularly salient. A national mental health crisis among college students in the U.S. is affecting U.S. higher education campuses as more students arrive on campus with diagnosed disabilities and mental health conditions and request accommodations (Greenburg, 2022), making research on mental health and disabilities salient. Specifically, within engineering education,

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previous quantitative research indicates that engineering students have "high rates of mental health struggles" (Danowitz and Beddoes, 2018, 2020, 2022a; Jensen and Cross, 2021; quoted in Beddoes and Danowitz, 2022b), so further research is needed to understand student perspectives about their lived experiences.

Positionality

The primary investigator, Katherine, identifies as a middle-aged, white, cis-gendered, heterosexual, female, first-generation student who was recently diagnosed as neurodivergent with autism, ADHD, dyscalculia, and chronic anxiety disorder. This diagnosis emerged as a new identity through the collaborative research process described in this paper. Katherine is an adjunct faculty in the Humanities, Arts, and Social Sciences (HASS) at the location of the study, the Colorado School of Mines. The findings in this paper are from her doctoral dissertation research. The second author, and Katherine's mentor, Jon, identifies as a white, cis-gendered, heterosexual, able-bodied male who identifies as neurotypical, and was a first-generation college student.

Engineering Education Culture

This study focused on professional engineering culture, which was theorized by Seron and colleagues as contributing to the lack of gender diversity in engineering (2016). They found that the women in their study reproduced the culture through a process of socialization, which maintained disciplinary sex segregation. Other studies also show that the established beliefs and rituals deeply embedded in engineering culture create a sense of identity for engineers, which is then leveraged to justify exclusions (Cech, 2013). Godfrey and Parker (2010) showed that this meritocracy extends globally and that there are common characteristics such as a reliance on mathematics, positivism, and reductionist thinking that prioritizes measuring and quantifying for practical utilitarian problem solving. In engineering education, the cultural narrative is historically based on notions of surviving extreme rigor (Riley, 2008) that is shared as a cultural sense of pride and identity in professional engineering across U.S. campuses (Cech, 2014). Pedagogical assumptions about the effectiveness of extreme rigor and overcoming difficulty are central to engineering education and are reproduced in the culture that students experience and are socialized into. This narrative on engineering education includes managing an overwhelming time-consuming workload that is often described as "horrific" and "living hell" (Godfrey & Parker, 2010, p. 12). Mental health impacts of such a culture merit further study.

The limited research on mental health completed specifically in engineering education used quantitative methods (Cross & Jensen, 2018; Danowitz & Beddoes, 2020; Jensen & Cross, 2020) and shows that engineering students experience higher rates of mental health issues like panic disorders, PTSD, anxiety, and depression compared to students in other majors regardless of identity. However, rates of mental health disorders climb substantially for both white women and women of color, but also for bisexual women, who have panic disorder at eleven times the national average (Danowitz & Beddoes, 2020). Cross and Jensen (2018) found that students promote a culture of stress through identifying stress with engineering education and their emerging professional identities. The authors used a survey of 1,203 undergraduate student participants at one large public university's engineering school to identify the contingent relationships between a student's identity in their major in relation to their perceptions of stress and inclusion. They found that engineering students felt *pressure to claim group stress and anxiety as part of their identity as an engineering student* to feel like they fit in (Cross & Jensen, 2018). That is, stress and anxiety become a way of being and of belonging. Additionally, a 2020 study determined that female and first-generation students' mental health is affected by their sense of

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belonging in their engineering programs (Jensen & Cross). The extant research shows that engineering educators cannot ignore the cultural barriers if they want to meet their goals of increasing diversity in engineering education and the professions (Cech, 2013; Haverkamp et al., 2019; Lord & Camacho, 2013; Ma et al., 2017; Mayes, 2014; Seron et al., 2018; Slaton, 2013).

Despite public perception that the extreme rigorousness and suffering are reasons why students do not choose engineering (Kennedy et al., 2018), there is relatively little research on the mental health implications on students who experience stressful environments as they become engineers (Coley & Jennings, 2019; Cross & Jensen, 2018; Danowitz & Beddoes, 2020). Further studies are needed on individual experiences of underrepresented engineering students, and in particular, scant research exists on the experiences of queer women of color (Jennings, Roscoe, Kellam, & Jayasuriya, 2020). There is also an absence of research on disabilities in engineering (Slaton, 2013; Svyantek, 2016), but also a dearth of research on neurodiversity in higher education broadly (Stenning & Rosqvist, 2021) and in engineering education specifically (Cueller, Webster, Solanki, Spence, & Tsugua, 2022). To these ends, an intentionally broad research question for the study was created to guide the study: *How do underrepresented students experience the culture of engineering during their education?* However, given the hegemony of positivism in the culture, pedagogies, research, and epistemologies in engineering education, a culturally responsive (Berryman et al., 2013) qualitative methodology was purposively theorized and implemented for the study. To this end, the study included a second research question: *How did the unique methodological approach work to answer the first research question?* However, the methods and theories are not the focus of this conference paper, which examines the findings on the mental health impacts that emerged from the first research question. In the next section, we briefly explain the novel methodological framework that was used in the research, which produced the participants' narratives and findings.

Methods and Theories of Creative Materialism

The unique methods and theories used in this study were theorized to fill the gap in the engineering education research literature that called for more interdisciplinary (Baille & Armstrong, 2013; Cech, 2014; Karwat et al., 2014) and first-person (Moloney et al., 2018) research approaches to better understand student experiences in their own words. Particularly, within the neurodivergent community, there are calls for more participatory research that permits neurodivergent students to share their stories in their own voices through narrative inquiry methods (Cueller, Webster, Solanki, Spence, & Tsugua, 2022). A unique conceptual framework was theorized for this study called *creative materialism*, which combined new materialist theory (Nail, 2021) with culturally responsive methodologies (Berryman et al., 2013), and arts-based research methods (Leavy, 2017). This framework required sharing power between the participants and researcher to collaboratively and materially generate new knowledge in the form of narratives. The goal was to provide new perspectives on why, despite decades of considerable effort to increase participation in engineering, some communities remain underrepresented in engineering education and the professions.

Briefly, culturally responsive research methodologies are grounded in critical theory but also the decolonizing education frameworks of the Māori of New Zealand called *Kaupapa Māori* (Berryman, SooHoo, & Nevin, 2013). This approach requires exposing the ideological and historical threads in educational research with a goal of humanizing research to counter generations of exploitive and extractive research practices with marginalized communities like the indigenous Māori people. In this study, power sharing occurred in several ways. For the conversational interviews, the participants helped create their own interview prompts. Participants also reviewed and approved the use of their

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own individual findings and how they were interpreted to form the study's overall findings, but they also reviewed and approved this conference paper. The framework also required deep ongoing self-reflectivity by the primary investigator about how her own myriad identities, including being an adjunct faculty member, affected her perception and interpretation of the participants' own emerging new knowledge about their experiences in engineering education (Nodelman, 2013). Arts-based research (ABR) methods (Leavy, 2017) use creative practices in social research because of their unique capacities for evoking and provoking new understandings and perspectives in an audience. Arts-based research methods are also culturally responsive (Nodelman, 2013) methods that were appropriate to this study and fit with the new materialist theory as a component of creative materialism.

The new materialist theoretical grounding of creative materialism provided an emergent process of knowledge production, referred to as "looping" (Nail, 2021). Nail's kinesthetic contemporary loop object theory updates the scientific method with a new epistemological and ontological perspective based on quantum field theory, chaos theory, and mathematical category theory. Nail's (2021) theory pushes those trained in western positivism to reassess their assumptions about objectivity and representation. In contemporary loop object theory, the process of coming to know emerges through the labor of the research itself through material and relational interactions; in other words, Nail formalizes the process of coming to know as "know-how" (Nail, 2021). Leveraging this theoretical grounding, the individual participants and the primary investigator shared and exchanged narratives and experiences. One of the end results of the study using these methods was a new and startling awareness of neurodivergence, in the form of autism, among all the participants and the primary investigator.

IRB approval for human subjects research was received at the University of Denver for the dissertation research but also from the Colorado School of Mines' Human Subjects Committee. The research was conducted during the spring semester in 2022 at the Colorado School of Mines, a small engineering-focused university in the western U.S. Criteria for student participation included having at least one underrepresented social identity, an interest in exploring how their social identities shaped their experiences of becoming an engineer, and comfort with the creative inquiry methods used. The participants were recruited through an email that was distributed by the Student Life office. Due to the qualitative methods of the study, the number of participants was limited to three with a goal of depth over breadth of data. Three undergraduate students responded to the email and were recruited in December of 2021. In 2022, four individual semi-structured conversational interviews (Zhang & Wildemuth, 2009) were conducted with each participant and recorded for transcription (12 interviews in total). Student participants kept weekly journals (Sheble, Thomson, & Wildemuth, 2009) and, as a form of power sharing (Berryman et al., 2013), regularly chose what to share as significant with the primary researcher. Each student participant also generated creative content in the form of drawings, paintings, poetry, and/or photography (Leavy, 2017), which were excluded in this paper due to space constraints, but this content will be shared at the conference presentation. Summaries of each student's data and content findings were provided back to them for their review and approval for use in keeping with culturally responsive methods (Berryman et al., 2013), and a focus group with all three participants was used at the end of the study to consolidate findings and create recommendations (Chauhan & Sehgal, 2022). Student participants were paid with a $100 VISA gift card at the end of data collection as compensation for their time, labor, and for sharing their lived experiences, which required a form of emotional rigor due to the creative materialist framework.

In keeping with the creative materialist framework that shaped the study, analysis was conducted with each student participant's interview transcriptions, their journal entries, and creative content by printing them as material artifacts. Analysis was an ongoing process in which each individual

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participant's previous data and content were then analyzed collectively by the primary investigator prior to each interview. Key words and phrases were highlighted in different colors to identify patterns, and then these key words and phrases were triangulated between content forms to identify the unique findings to each participant (Leavy, 2017; Nodelman, 2013). Interview prompts were generated from each round of analysis that were custom to each participant and were sent to the participant prior to the next interview; participants often reflected on the prompts in their journals and creative content, which we then later discussed in the next interview. In this way, data and content were continuously reviewed throughout the duration of the study by both the participants and the researcher, from which new knowledge emerged. Data saturation was detected through the repetition of key words and phrases by the end of data collection. These individual findings were then combined and further analyzed with the same methods to detect common patterns between the participant's experiences, but also to uncover differences that were significant between students. Below we offer short profiles of each participant to elevate their unique stories and identities; the profiles were approved by the participants. Each chose a pseudonym for the study and some details about them are excluded intentionally to protect their privacy.

Student Profiles

Esperanza

Esperanza was a sophomore student in the winter of 2022. She identifies as Christian, cis-gendered, female, heterosexual, and as multiracial and Hispanic but does not speak Spanish. Esperanza was diagnosed with a physical disability that causes nerve pain that impacts her hands and feet, which affects her ability to walk, write, and do lab work and results in physical exhaustion that requires her to rest to recuperate. She also is affected by asthma and anxiety. She chose not to disclose any of these traits to the school nor did she seek accommodations as she perceived accommodations would not be helpful for her and were reserved for students with greater needs than hers. As a result of her participation in this research project, Esperanza later sought a diagnosis for what she suspected was neurodivergence in the form of autism. Esperanza identifies as a first-generation student despite her parents having attended college for the performing arts. Her parents were children of immigrants from Europe and the Caribbean and as minority and first-generation students, they received an abundance of guidance and assistance through their college experiences and did not come away fully understanding the higher education systems and bureaucracy, and therefore were limited in their ability to guide her. Esperanza is the only person in her family to attend an engineering school. Esperanza worked three different on-campus jobs to help pay for her education while participating in the study. Esperanza was cognizant of her desire to actively increase participation in engineering by women and students of color. Her primary goal with participating in the study was to better understand her own multicultural identities and her experiences as a woman in engineering, as these identities are where she feels the most "different" in her education. She wants to be a role model and generate interest in the Hispanic community and among other minorities and females to become engineers.

Creek

Creek is a cis-gendered female student who was in her final year during data collection and graduated in May 2022. Creek identifies as queer/bi-sexual and a person of mixed racial ancestry. Her parents were both immigrants to the United States but are now US citizens. Her father is of south Asian and European ancestry and her mother is from Italy. While Creek's parents are college educated, she identifies with

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first-generation college student issues, as her parents were not familiar with the US system of higher education. However, Creek was unique among the participants as both her parents work in STEM education and industry. Her father is a professor of mechanical engineering and theoretical physics at an institution of higher education while her mother works in the computer science industry. Creek shared that their expectation was for her to major in a STEM field in college. Creek wants to follow in her dad's footsteps and become a college professor. Creek was diagnosed with an anxiety disorder and explained that she was transparent about her mental health experiences with peers and others as a way of normalizing mental health issues in STEM. She also later reflected on the possibility of her own neurodivergence as likely in the form of autism. Gender was salient for Creek as was her sexual identity as a queer woman in a relationship with a heterosexual man. Creek stated that her study participation goals included gaining a better understanding of the engineering meritocracy that she was socialized into by her parents that relies on the belief that only certain people are capable of being engineers— that is, that engineers are special and different than non-engineers.

Eilidh

Eilidh identifies as a cis-gendered, queer/bisexual, white woman who was in her junior year of college during data collection in the spring of 2022. While some of her older relatives attended college, she does not have generational knowledge of institutions of higher education. For this reason, she lived in a first-generation student themed learning community in the residence halls her first year at college. She is also from a low-income and working-class family and held multiple on-campus jobs to help pay for school and provide for herself. Part of Eilidh's stress at college included balancing her lack of financial resources with needing formal accommodations from the institution for her multiple physical and learning disabilities, which required medical documentation she could not afford. Eilidh was diagnosed with ADHD during her freshman year of college, and later a connective tissue disorder that causes constant chronic pain and her joints to pop and dislocate. This disorder affects her physical mobility, strength, and endurance. She shared that often she can barely get out of bed, and frequently needs time to recover from exhaustion. These physical differences are invisible to most people outside her circle of friends who know her and who accommodate and support her. She also has dyscalculia, or number dyslexia, which makes mathematics a challenge for her despite her comprehensive understanding of the associated mathematical concepts and processes. She also has memory issues and aphantasia, or the inability to visualize things in her mind. She explained that she does not think in images or words but must think out loud while speaking. Initially, she described herself as having autistic leanings, but not a formal diagnosis. She decided during data collection to get an evaluation and was diagnosed as on the autism spectrum by our last interview. Eilidh's queer/bisexual identity was salient during her data collection as she explained the various stigmas within the LGBTQA+ community about her currently dating a heterosexual male student. She was a strong advocate for members of this community and for women in STEM and was particularly concerned about safety for transexual students and sexual assault on women. Eilidh was interested in understanding how her various identities intersected with each other but also with the institution. She noted that there are outreach and support programs at the college for a range of underrepresented identities, but none for someone like her with *multiple* complicated identities. She stated that she must handle a lot on her own and wanted to know how it was impacting her as she navigates her education. She also wanted to better understand how the institution works and how she is supposed to interact with the school to get the necessary assistance and accommodations for her differences. Like the other participants, Eilidh was motivated to make changes in the culture so those with similar identities who come after her will have more accessibility and a more informed, sensitive, respectful, and supportive climate.

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Findings

Participants' data and creative content illustrated their understanding and experience of the culture of engineering, including that of extreme rigor, and its impact on their mental health, a finding consistent with other studies on this issue (Coley & Jennings, 2019; Danowitz & Beddoes, 2020; Jensen & Cross, 2021). Six major themes emerged in the data related to the mental health impacts of being an underrepresented engineering student:

1) a sense of not belonging;
2) student reproduction of the culture of stress;
3) additional labor that is invisible and unacknowledged;
4) fear of being weeded out;
5) burn out and mental exhaustion; and
6) modifications toward self-care.

The students' narratives showed the mental health significance of the how their identities shape their experiences with the meritocratic culture that relies on a limited range of pedagogies for evaluating and weeding out students (Bucciarelli, 2009). The study participants demonstrated how they were actively modifying the weed out and culture of extreme suffering through their own practices of self-care, but also how they were refusing to reproduce the culture with other students. They often shared their stories of their struggles to create a community of caring and support for their peers, which was also evident in their participation in this study.

Not Belonging Despite Ability

The findings of the collective data and content created by the students showed that they all arrived at college with strong STEM identities, which previous research showed was important for successfully navigating STEM as a female student (Rice & Alfred, 2014). All three women enthusiastically accepted their place amongst like-minded scientists, engineers, and mathematicians and thrived in academic settings that were supportive of their own interests and professional goals. For instance, Esperanza expressed how it felt to be in a community of engineers as a first-generation student. "*I did that summer program here through the multicultural program and I just fell in love with the community. And all the other kids that I met, like I hadn't really found a group in high school that was interested in engineering. And so, to come here and find a group, of multicultural people especially, that were interested in engineering and math, it was super exciting for me.* Given their strong STEM identities, one of the common findings for all three women were emotions like confusion, uncertainty, anger, and resentment as to why they were at times made to feel like they did not belong at the school when they know they merit their place due to their strong interest in STEM, their hard work and dedication to mastering content and skills, and their consistent grades.

As one example, all three participants described how female students are often challenged by male peers on campus that they do not belong. For example, Creek shared, "*I think there's some resentment from that that lingers in students… I've had friends who were told you only got in here because you're a woman. And they responded, okay, let's compare stats. And of course, they're better than these men".* Through the data collection, the participants gained clarity of how they experienced the culture through their various identities and were often made to feel like they did not belong. Creek noted in an interview that she knows that her experiences are not well understood by other community members. "*They don't even realize when they are doing these things. I think it gets irritating when they're not willing to change*

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their minds. Because there's a certain level of forgiveness too. They've just never known and that's okay. But if they're not ready to hear it, that's frustrating".

Student-Reinforced Culture of Extreme Rigor and Suffering

All three participants explained how they saw the culture of extreme rigor and suffering perpetuated by the students themselves, which aligns with Cross and Jensen's findings (2018). Creek reflected on this constantly reproduced culture of suffering. *"I feel like there is an expectation to be stressed. We joke about it, we revel in it, we relate about it"*. During the first interview, Creek reflected on how she experienced the culture of ranking and measuring herself against others and the implications while also noting that it is through competitive ranking of GPAs that students are accepted to this elite institution. *"I think that I'm a very competitive person… But if I keep measuring my life that way, it's never gonna stop. We all want to be the smartest person in the room… I mean, it's how we got here. I remember coming in freshman year, and people talked about that ranking like it was part of them".* During the second interview with Creek, we discussed the culture's implications for student mental health and well-being and she pulled open the top drawer of the desk where she was sitting and shared what had already been written inside*: 'this school makes me want to die'.* She continued*, "It's an expectation that we don't like being here. To a point where if you don't have something to be upset about its kind of weird*." Creek noted in the final interview that the struggle creates a bond between students, but that "*maybe it is not the best for us to always be like trauma bonding*." However, beyond the culture of suffering that is reproduced by students, the study participants indicated that underrepresented students carry additional burdens that exacerbate the existing pressures on their mental health.

The Unseen Extra Labor of Underrepresented Students

A robust collective finding that emerged from their narrative data was of the additional labor the participants exerted to succeed in a culture that does not recognize their differences. The participants often described feeling exhausted and having a desire to just be themselves without questions from people who do not understand the differences in their experiences. This finding was particularly salient in terms of pedagogies that are not cognitively inclusive. Because of her ADHD, Eilidh explained that there does not seem to be a pedagogical approach that accommodates the way she thinks. "*I'm not a narrow-it-down person, I'm a build-the-web person. I can't just like funnel it all down to like a target. I'm building a web*". Because of her dyscalculia, Eilidh understood her own limitations. "*I lose points for a lot of things because of number errors. Like I will flip numbers around in the wrong order, even if they were right earlier. Or I will just write down the wrong number".* Eilidh shared in the last interview how friends and faculty were confused by her grades compared to her verbal ability to explain subject matter. *"I can't communicate that I know it with the way it's measured. My presentations are always really good and that's how I can tell you I know things".* Eilidh expressed in her journal in late January what it felt like to attempt homework when she is exhausted because of her physical disabilities and neurodivergence, *"It felt like trying to catch smoke with my hands."* During the first interview, we discussed how her difficulties made her feel. "*It's so bad. I know that just mentally I'm at a disadvantage because I have more to handle within my brain than they do. Logically, I know that; emotionally it stings like a bitch".* In the second interview Eilidh expressed how the lack of support and the informal culture of suspicion around accessibility was dehumanizing. Because most of her disabilities are not visible, she expressed that "*People don't know I'm disabled. They're never gonna know [unless I explicitly tell them]. A lot of times people figure out I'm disabled, and their first reaction is pity, like, I'm sorry, that's happening to you".* Esperanza also suffered from physical disabilities that were unknown to most people. She explained how sometimes she needs a break. "*Sometimes I'll have flare ups that are just*

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caused by nothing. And like, it hurts to do everything, to just exist". Esperanza came to understand through our collaboration how her physical disabilities affected other health problems and her mental health as well. *"Like even, I think that goes with anxiety, too, and asthma and all that. Like, it's all kind of tied together".*

Another consistent finding from all three participants was the invisibility of economic differences between students and particularly the invisible labor that low-income students exert to pay for their education and expenses. This issue was particularly salient for Esperanza, who shared how people were surprised that she was working three jobs while going to school full-time. She explained that she did not have a choice as a student from a lower socio-economic background who sends money to her parents and that explaining her situation to people was often frustrating. "*They're like, you need to focus on school. And I'm like, yeah, I totally get that this is a hard school, but I also have other things that I need to prioritize".* Creek explained how she thinks that diversity efforts are suspicious in the engineering meritocracy and that she felt that the experiences of underrepresented students are not known or appreciated because of the cultural beliefs that a student attains an engineering degree based only on their own effort. "*When you get diversity initiatives of bringing in people based on identity, [others think that] that's not hard work. You didn't work to be black; you didn't work to be a woman".* The extra labor of navigating a sense of not belonging is invisible to many members of the campus community because they do not share these experiences of marginalization and are therefore suspicious of claims from underrepresented students that they are having different educational experiences.

Fear of Being Weeded-Out and Associated Mental Health Implications

The term "weeding out" is not an explicit part of the school's culture, yet each participant had heard the term and knew they were being forced through this process though they were unsure as to why. Creek, wrote in her journal how she understood the purpose of these practices, "*Their only intention is to be as hard on you as possible, to prepare you to figure out if you're destined for this school, to just beat you into the dirt until you're good enough for us.*" Eilidh shared in the first interview that the weed-out classes make the school the enemy of the students and creates resentment toward faculty and staff "*who are trying to make our lives miserable.*" Esperanza voiced concern and uncertainty over the socialization process that includes failing a specific percentage of students as a form of rigor. "*Yeah, I was really upset when I heard that. It's like what about us? We're doing everything that we can. Or at least in my case, I'm doing everything that I can to succeed*". An outcome of a weed-out culture is that it creates suspicion about the intention of such a program with Creek stating that it makes the school the enemy, that "*they did this to us.*" The school's weed-out program also negatively impacted student learning due to the fear it generates.

All three participants expressed their intimidation of asking for help or asking questions for fear of appearing stupid, and therefore potentially being weeded out. Creek shared in the first interview that there is a culture of fear around looking dumb that inhibits learning. "*I think people are afraid of seeming like they don't get it. They just pretend that they get it and move on".* Eilidh described her hesitancy to, as she put it, ask faculty to "*dumb down*" materials for her so she could understand them with her learning disabilities. Esperanza shared how she also hesitates to ask questions. "*I don't want to look stupid in front of everyone. So, if I'm not 100% certain that it's right, I'm not going to say anything, or give my answer, even though it would be much more beneficial to get it wrong in front of the class, and then learn from your mistake".* All the participants rejected this cultural feature as not aligning with their own values but also as contradicting the school's stated values around mental health. During her interview Eilidh described the toll that the extreme rigor has on student mental health. "*We all kind of*

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go through a roller coaster here. I think the school acknowledges that it's hard, but that we'll thank it later when we get a good job. And it's exhausting to constantly hear them say you'll value this one day. But you know what I value right now? My health, my sanity, my ability to go to school". Like the other participants, Esperanza expressed uncertainty as she explained that she feels she has a different learning style, which she later came to realize was neurodivergence, and that asking for help from professors created anxiety and unease. "*I think it's part of like the stigma of I don't want to need support, even though I need it. And I think that's something that is common here to where it's like, I should be able to handle everything. And so, when I can't, it's almost embarrassing.*" Esperanza noted in the last interview how the weed-out classes affect low-income students unfairly as they cannot afford to retake courses. "*So, like, no wonder we don't have a lot of low socio-economic students. Because especially if you weren't given the opportunity to learn how to study, then you're failing more classes, and you have to pay for them again".*

A Culture of Mental Burn Out

The culture of burning out was illustrated during the research with Esperanza, for whom extreme rigor meant limited flexibility for an emergency that arose for her during the semester. "*[STEM] classes are not as flexible as we sometimes need them to be. Like, things come up with life. And it almost seems like we just need to prioritize being a student over everything else.*" Interview two occurred in mid-February and Esperanza explained that she had missed a few classes and was behind on her work and expressed concern and hesitation at emailing her professors for extensions because of how they might perceive her and how it could affect her grades. "*I'm really nervous about emailing my professor, because I don't know how they're going to take it".* By the final interview in May she indicated that she was extremely stressed out, fatigued, and worried about her grades. "*And it's just like the worry if I miss this day of class, then I'm gonna have so much more to do in the future".* She explained that the mental health guidance she had received, which was to take as much time as she needed to recover from the trauma of another student's attempted suicide, was unrealistic. "*I feel like [the school] has a culture of just go go go. Like, there is no room to be human or to have emotions or to deal with things".* For her, taking time off meant falling behind on assignments and exams, which created more stress. All three participants expressed exhaustion during the semester of the study and required flexibility in our meetings for interviews to accommodate their stress and mental health needs.

Modifying the Culture for Community and Self-Care

When asked how they would change the culture and their university experience, all three participants returned repeatedly to their need and *desire for community* rather than a focus on their individuality. The women were not seeking an engineer identity—they arrived with their own reasons, skills, drive, and ambitions for participating in engineering education. Instead, they sought communities across the various aspects of their lives including their personal lives, academic/student lives, in their student jobs, and in their imagined future professions. For Esperanza, her best learning took place when she felt safe to ask questions without appearing inadequate or unqualified and therefore potentially weeded out. She noted the differences she experienced with the doctoral student who supervises her in her research job because he was patient answering her questions "*I felt comfortable, it wasn't ever awkward, I never felt stupid for asking the questions".* In terms of her future career in academia, Creek explained that she wants a community of minds and practice. "*We're setting up the work for future generations to finish what we started. It's supposed to be this huge exploration of life, and we're all in it together".* Creek expressed in the final interview how she was surprised how much community and relationships mattered to her. She shared how she now understands that support networks were necessary to

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persevere. "*It's part of the social aspect that I've been learning here, that you need other people to help you. Not just to be like, I don't know how this problem works, but to be like, I need a collective of minds to get this problem done.*" Creek reflected on her goal of becoming a caring, empathetic, and approachable professor in contrast to the existing weed-out and extreme rigor culture. Creek also voiced in the final interview how important it is for faculty to be caring and human. "*The professors that I've enjoyed most and gotten the most emotionally out of class are the ones that are most engaged with students, that actually care about us, and that are open. They're actually transparent about how they're feeling*". Creek also described how faculty sharing their own struggles transforms students' perceptions and treatment of faculty. "*We see them as more human, so we are less critical of them. We're less rude. But we also go, oh, you're struggling too… it's okay for me to struggle.*" For Eilidh, community means people who know her and her differences and accept and accommodate her without her having to educate, ask, or feel vulnerable. Eilidh had to adjust her expectations for herself and learned she could not compare herself to neurotypical students. "*Instead of saying I need to do better than everyone, I started looking at the average. And really just telling myself that my goal for college is to get through college*".

The participants shared how they had to develop their own self-care routines and practices that ultimately improved their well-being. These practices were centered on taking breaks from being a student, like reading a book for pleasure or a trip off campus. Creek noted her shift in understanding what activities make her happy and why in her journal in February and that her happiness was no longer tied to her GPA. "*I'm happy when I'm reading books and talking to my best friend about rekindling our childhood love of books*". During the orientation interview, Creek described how other students often fail to recognize how to take care of themselves. "*We don't value self-care… And then they get so caught up in school that they're like, oh, I forgot the only meal that I've had today is caffeine. No wonder you're not feeling good. No wonder this is difficult for you right now. Take a break and eat*". Esperanza found through the research experience the value in leaving campus regularly. In the final interview we discussed the photos she had taken on a trip to the mountains with friends as part of her creative content for our study. She explained that she realized leaving campus was necessary for her mental well-being and recovery from the trauma of the semester. "*I had been on campus for like two months. Like I hadn't left and so I went on a weekend trip with a bunch of friends. And it was just so good to get off campus and not worry about school, not worry about responsibilities*". She took pictures of the winding mountain roads from the front seat of the vehicle and explained that with our research on her mind, she reconnected with her earlier love of roads and infrastructure through taking photos. "*I think going back to some of the [interview] questions, a lot of my life is school. Whether it's work or whether it's academics, it's a lot of just thinking about school and worrying about school. It's really important to get out and take care of yourself and I think I had neglected that for a long time*". By the focus group at the end of the research, all three participants had come to better understand their own experiences with the campus community.

Discussion

Findings from participant data support the existing research on underrepresented student experiences in engineering education and specifically on the impact that the cultural emphasis on rigor and suffering has on the well-being and mental health of engineering students (Jensen & Cross, 2021). Other studies have shown how the culture creates feelings of not belonging for students with a range of underrepresented social identities (Cech & Waidzunas, 2011; Cueller et al., 2022; Harper, 2010; Haverkamp et al., 2019; Lord & Camacho, 2013; Rice & Alfred, 2014; Riley, 2008, 2013; Seron et al., 2015, 2018; Slaton, 2013; Stonyer, 2002; Tate & Linn, 2005). The poignancy of the participants'

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confusion, frustration, and anger at being made to feel that they do not belong *because* of their identities was particularly salient. All three *knew* they belonged at this elite institution, and their data and content signified the mental health impacts and extra labor they put in to overcome challenges to their sense of belonging.

To this end, the participants were all clear that they want the culture to change, and to do so requires adding new stories to the culture. At present, a weed-out culture is not a formal or official pedagogical practice, but instead hides invisibly in the cultural narrative of extreme rigor. Additionally, as all institutions of higher education across the U.S. are experiencing, students will continue to arrive at campuses with diagnosed disabilities and mental health that require support (Greenburg, 2022). Further research is needed on disability student services in higher education and in engineering education. All three students were unclear on the process, expectations, agendas, and purpose of disability services, so more work is needed to make these services and their legal and liability risks and concerns visible to educators and students to address these new challenges (Chrysochoou, Zaghi, & Syharat, 2022). The same is true of mental health programs in higher education generally and engineering education specifically (Jensen & Cross, 2021). Below are some specific ideas on how changes in the culture could occur based on the study findings.

Sharing Narratives and Shifting Organizational Sagas Toward Dignity for Differences

To meet their goals in diversity, inclusion, and access initiatives as well as mental health initiatives, engineering campuses must change their organizational saga (Clark, 1972) through storytelling and sharing underrepresented student experiences, both their struggles and their successes. Student differences are often invisible, but so are the *mental health impacts of not belonging*, as Jensen and Cross also found (2020)*.* Making these differences known and understood is necessary to reduce the suspicion that many underrepresented students encounter from peers, faculty, and administrators who exist comfortably in the existing meritocracy and culture (Godrey, 2007; Haverkamp et al., 2019; Heybach & Pickup, 2017; Lee et al., 2020; Mayes, 2014; Riley, 2013; Seron et al., 2015; Tate & Linn, 2005). Trust and support for students with neurodivergent and cognitive differences requires accepting their limitations and providing reasonable accommodations without inferences of "cheating", which in turn provides dignity for these students (Chrysochoou et al., 2022; Cuellar et al., 2022; Taylor et al., 2019).

Campus cultures must honor the robust STEM identities (Rice & Alfred, 2014) along with the other social identities students arrive with, rather than prioritizing and rewarding extreme devotion to gaining an engineering identity and to being a student over all other aspects of their complicated lives. Research in industry recognizes the importance of diversity in the workforce. A 2023 Rand Corporation report (Weinbaum, Khan, Thomas, & Stein, 2023) argues that not only are there neurodivergent people working in the national security and military sectors, including engineers and scientists, who hide this stigmatized identity, but also that there are some missions that require the strengths of those who do not think in typical ways. Taylor and colleagues (2019) also argue that the culture of engineering actively discourages the creative thinking that neurodivergent people often excel at despite creative thinking being a crucial component of innovation. The campus cultures must also add self-care as a cultural value crucial to succeeding and meriting a degree, rather than surviving extreme suffering. Students should be seen as full adult human beings with complicated lives. Faculty should create reasonable flexibility in their class schedules for exams and assignments, as is expected in most industry workplaces (Chrysochoou, Zaghi, & Syharat, 2022).

Redefining Rigor and the Meritocracy

As the participants' findings showed, rigor is central to engineering education's conception of producing qualified professionals for industry (Godfrey & Parker, 2010; Leydens & Lucena, 2018; Lord & Camacho, 2013; Riley, 2008, 2013; Seron et al., 2018; Slaton, 2013). The term rigor is problematic as it has become epistemologically embedded in higher education across academic disciplines, curriculums, and research in general (Riley, 2017) and used as a ubiquitous adjective to signal validity in education programs and research. Changing definitions and the culture around concepts of rigor will be difficult as it is associated with positivist notions of validity in research (Douglas et al., 2010) and contributes to the resistance to pedagogical change (Leydens & Lucena, 2018), as rigor is assumed to be necessary to produce competent engineers (Riley, 2017). Because rigor is used by faculty as a tool for "weeding out" (Godfrey & Parker, 2010) and to identify and eliminate any students who struggle to persevere in their programs, this type of "sink or swim" approach leaves no room for helping those struggling because doing so is believed to reduce the rigor of the program that is necessary for creating competent engineers (Riley, 2013).

Rigor, when conceptualized as a process of physical and mental endurance, does not account for the *invisible extra labor* that underrepresented engineering students must produce in a culture not created by or for them. This type of rigor assumes a meritocracy in which all students supposedly start a metaphorical race on the same starting line. Historically, engineering culture was designed by white, able-bodied, heterosexual males (WAHMs) for other WAHMs (Cech, 2022) with meritocratic ideologies (Cech, 2013, 2014). That is, underrepresented students exert hidden efforts that the current engineering meritocracy does not know of, value, account for, or understand.

The pedagogical cultural reliance on positivism and excessive testing is extremely challenging for students who are neurodivergent with (for example) ADHD, dyscalculia, and autism (Chrysochoou, Zaghi, & Syharat, 2022). The teaching of abstract mathematical and theoretical concepts and equations without context (Bucciarelli, 2009) along with evaluating and sorting students through testing based on accuracy does not accommodate differences, whether neurological or cultural. Traditionally, this form of pedagogical rigidity is entangled with the cultural notions of rigor, weeding out, and the meritocracy, which creates a sense that accommodations are special treatment that produces less qualified engineers (Slaton, 2013). This pedagogical approach also rests on the assumption that only some people can be engineers and that these people have natural gifts and affinities for mathematics and problem-solving that cannot be taught, but instead emerge through testing, or weeding out (Riley, 2008). All three participants questioned these assumptions and cultural values.

Conclusion

This unique study contributes to several areas of scholarship about the experiences of underrepresented students who are socialized into the culture of engineering and how they experience the rigorous weed-out culture that is the basis for the historical narrative that supports the engineering meritocracy (Riley, 2008; 2017). Particularly, we showed how these participants' complex intersecting identities require extra effort on their part that remains unseen and unacknowledged by others, which contributed to their sense of not belonging despite their strong STEM interest and abilities. However, the participants also showed how they learned to adapt in response to the culture and to care for themselves but also how they model the type of culture they believe is more supportive of students to create healthier learning environments. They demonstrate a different type of rigor and meritocracy of perseverance and

advocacy (Riley, 2017) so that they can create the change they see as necessary in engineering education for future underrepresented students in engineering to thrive and feel that they belong.

Recommendation for Mental Health Research

There is very little mental health research in engineering education, but also about the current student generational mental health issues that are emerging in higher education more generally (Greenburg, 2022). Further research is needed related to the findings of this study, including:

- Examining the policies and legal framework that are barriers to campus counseling centers offering ongoing chronic care in addition to acute care; future students will come in with diagnosed neurodivergence and mental health conditions that need ongoing support.
- Gathering data from the student body on diagnosed learning and physical disabilities as well as disorders like anxiety and depression to better support this population.
- Collecting data on students from low socio-economic backgrounds and the stresses related to paying for school as well as working multiple jobs as a student to support this student population. These financial differences must also be examined with the disability accommodation process that requires medical validation, which some students cannot afford.
- Examining the diversity of counselors at counseling centers for representation gaps in community care.
- Conducting research with faculty about their understandings of how recent generations of students are experiencing but also informed about mental health, including diagnosis.
- Assembling data on faculty and administrator's understanding of cultural and other differences underrepresented students experience in the culture of engineering.

Finally, we close the paper with what faculty can do to make a difference:

- Assume that each student is different and unique; don't generalize that there is one type of student, let alone engineering student.
- Be attentive to students describing problems with their work; there could be undiagnosed neurodivergence they are not aware of and struggle with or cultural learning differences.
- Clearly lay out your goals and expected outcomes and communicate clearly with students throughout the semester if things change. Do not arbitrarily change the schedule or assignments— be organized and consistent.
- Take the time to explain the class and its purpose and how students will be evaluated. Many students need the larger context to understand what they are expected to learn.
- Ask your class how they are and if they are taking care of themselves; model and promote mental health to counter the extreme rigor narrative that does not help with learning.
- Provide flexibility with due dates and assignments when possible.
- Provide a range of testing and evaluation methods to account for learning differences including oral exams. Consider other forms of assessment that can more fully evaluate a student's overall learning and abilities.

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