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’Engineering is Hard’: Identifying Sources of Difficulty Faced by Undergraduate Engineering Students

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I. Introduction

The perceived and actual difficulty of engineering has long been a defining characteristic of engineering. Engineering programs are often described as among the most rigorous in higher education, marked by heavy workloads and complex problem-solving [1]. While academic standards are necessary for preparing students for the technical demands of the profession, the culture of engineering education has been called a 'culture of stress' because of its intensity [2]. Moreover, research has shown that a culture focused on 'weeding out' students, rather than supporting them through challenges, can disproportionately impact underrepresented and marginalized groups [3]. Feelings of being unwelcomed, not smart enough, or having to compete in a 'survival of the fittest' environment have all been linked to student attrition [3].

The metaphor of the "problem iceberg" was introduced by Seymour and Hunter [4] to describe the difficulties reported by students in engineering, regardless of whether they persisted in the major or chose to leave. Interestingly, both groups reported similar challenges, suggesting that the decision to stay or leave did not significantly alter their experiences [4]. Students commonly reported poor quality of teaching, a competitive and unsupportive academic culture, and problems related to the overall curriculum design [4]. Similarly, Santiago and Hensel [5] studied a significant portion of first-year engineering students that chose to transfer out of engineering between 2007 and 2010 at one large institution. They found that the most frequently cited reason for leaving was a mismatch of interests (22%) followed by academic difficulties or the perception of failure (18%), suggesting that many departures stem from students feeling misaligned with the field or overwhelmed by its academic demands [5].

The notion that relentless struggle is an inherent part of becoming an engineer has normalized burnout and high attrition rates, blurring the line between healthy challenge and severe struggles that undermine student success. Indeed, engineering plays a vital role in society, from building infrastructure, to driving technological innovation, and advancing healthcare [6]. As such, engineers must be highly competent and well-equipped to meet these demands. However, students should not be expected to endure the outdated stereotype of merely 'surviving' engineering school nor to accept severe mental health challenges as a normal rite of passage in their education. At present, scholarship has not yet reconciled this need to develop highly competent engineers with the need to support their mental health. We aim to fill this gap by offering a framework for the sources of difficulty that undergraduate engineering students face. In doing so, we aim to add nuance to the conversation about difficulty in engineering, helping practitioners identify the kinds of difficulty their students face and the kinds of support their students need to overcome those difficulties.

This study builds upon prior work from the author team, which investigated engineering culture during the pandemic [7]. Deters et. al [7] found that the types of difficulty that engineering students discussed came from different sources that could be categorized as intrinsic (i.e., difficulties that are inherent to the content) or constructed (i.e., difficulties that are added on based on factors like teaching styles, assessment styles, and environment). We use our prior work as a starting place for analyzing new data to identify the sources of difficulty that engineering students face and develop a conceptual framework for "hardness" in engineering. To this end, this study investigates the following research question:

> What are the sources of difficulty in engineering that contribute to students' perception that 'engineering is hard'?

Our work contributes to ongoing conversations about attrition in undergraduate engineering programs and offers a new tool for identifying which forms of hardness are intrinsic to engineering and which are contrived. Understanding and addressing the root causes of this difficulty is essential for strengthening both the engineering workforce and the quality of undergraduate engineering education.

II. Background

What makes learning difficult?

Understanding why engineering is perceived as difficult begins with how the brain processes and retains new information. Research on neuroplasticity demonstrates that the brain rewires itself and form new neural connections [8]. However, it takes repetition and practice for these new neural pathways to develop and create noticeable improvements in brain performance [9]. This process explains why learning new concepts takes time and can be challenging for some [9]. Building on this foundation, cognitive load theory posits that the brain has a limited capacity for processing new information at any given time [10]. When learners encounter multiple unfamiliar concepts simultaneously, such as syntax, logic, and functions in a new programming language, the resulting cognitive overload can impede comprehension and retention [10]. Understanding these principles is especially relevant in engineering education, where students are regularly expected to integrate new mathematical, scientific, and domain-specific knowledge concurrently, establishing a baseline level of difficulty that is inherent to the learning process itself.

What makes engineering difficult?

The cognitive demands described above are compounded by the specific structure and culture of undergraduate engineering programs. The typical undergraduate engineering curriculum is known to involve foundational concepts in mathematics and science, such as calculus and physics, with engineering-specific concepts such as thermodynamics or materials science. Students have reported increased difficulty within these courses and researchers have documented the numerous obstacles they face including understanding the concepts themselves, limited access to tutoring, or a lack of availability from professors [1]. Students commonly used terms like "a nightmare," "insane," or "living hell" to describe the coursework involved in studying engineering [1]. Godfrey and Parker [1] further explain that the perceived 'hardness' of engineering stems from the structure of assignments—often open-ended questions where the answer is never quite good enough to earn full credit. Students describe feeling thrown into projects and assignments without sufficient context on what to do, a pattern that faculty acknowledged. These difficult aspects of engineering have been corroborated by other researchers (e.g., [2], [7], [11], [12]) and shown to impact students' identity, sense of belonging, and mental health — outcomes that have been consistently linked to retention in STEM fields.

What makes students leave engineering?

These cultural pressures, combined with the academic demands of engineering coursework, have been directly linked to students' decisions to switch out of their major, or leave the field altogether. Research has documented various reasons behind this departure. Seymour and Hunter [4] found that the main issues students were facing were problems in course design, poor quality of teaching, lack of peer support, and negative classroom environment. Both students who persisted in engineering and switched to other degrees reported 'poor teaching quality' as a problem [4]. Students also reported a lack of attention to lesson preparation and organization, resulting in massive confusion when it came to learning and understanding the material. Together, the current literature demonstrates that retention and attrition is an ongoing concern in engineering. Literature further demonstrates that cultural norms – like a heavy workload, climate issues, and teaching issues – contribute to this retention and attrition problem [4]. These cultural norms and retention problems have led to engineering being characterized as 'hard' and 'difficult.' We investigate the sources of this difficulty, aiming to tease apart the different types of difficulty that students might encounter.

III. Methods

This qualitative study conducted with 21 undergraduate engineering students draws on semi-structured interviews, which explored their undergraduate experiences within a college of engineering. We draw on thematic analysis to identify different sources of difficulty within engineering education and their perceived impacts on students' experiences.

Setting and Participants. This study was conducted at a large, public, research-intensive university in the Midwest. Participants were recruited through departmental emails and by hanging flyers throughout the engineering buildings on campus. The participant pool was a diverse group, consisting of students who identified with at least one identity that is typically underrepresented in engineering, including being from low-income household (i.e., less than $70,000 per year), student of color, gender minority, or part of the LGBTQ+ community [13], [14]. A total of 21 undergraduate students were recruited to participate and share their experiences in engineering. A summary of participants' demographic backgrounds is provided in Table 1; we only provide aggregated demographic information to protect participants' confidentiality. As shown in Table 1, the participants also come from a variety of majors, including mechanical, civil, electrical, and other engineering disciplines. This diversity is important when analyzing the data, as it highlights that despite their different fields of study, students often encounter similar struggles and challenges in their learning experiences.

Table 1: Demographic Information for Participants ($n = 21$)

Demographic Category	**Group**	**Number of Participants**
Gender	Woman	11
	Man	5
	Other (Non-binary, Transgender)	5
Race/Ethnicity	White/European American	15
	Black/African American	2

Demographic Category	Group	Number of Participants
	Native American/White	2
	Asian/Asian American	1
	Middle Eastern/North African	1
Household Income	More than $70,000	14
	Less than $70,000	3
	Less than $30,000	4
Major	Mechanical Engineering	10
	Civil Engineering	5
	Other (Electrical, Chemical, Computer Science, Biological Systems)	5
	Not Specified	1

Data Collection. Data were collected through hour-long, semi-structured interviews conducted by the third and fourth authors in April 2023. Participants had the option to complete the interview in person or via Zoom. Prior to data collection, the study received appropriate Institutional Review Board (IRB) approval, and all participants provided informed consent. The purpose of these interviews was to gain a deeper understanding of the undergraduate engineering student experience and the challenges it entails. The interview questions relevant to this study included: "*What have you found to be particularly challenging about being an engineering student?*" and "*Can you recall any experiences when you felt like being an engineering student negatively impacted your mental health?*" Upon completion of the interview, participants received a $30 gift card.

Data Analysis. All interviews were audio recorded and transcribed using a transcription software. These transcripts were then cleaned by members of the research team to correct transcription errors, ensure accuracy for analysis and remove identifying information. All participants were assigned pseudonyms. In addition to the transcripts, the interviewers took detailed notes during each session and documented their own reflections afterwards to support analytical depth and reflexivity. The first and second authors of this paper did not conduct interviews and began their engagement by reviewing relevant literature to ground their understanding in existing research and to approach the data with contextual sensitivity.

Researchers employed an emergent coding process rooted in an inductive approach to thematic analysis [15]. Rather than applying a predetermined codebook, the team allowed themes to arise organically from the data to preserve the authenticity of student experiences. The process began with multiple close readings of the cleaned transcripts to develop familiarity with the content and context of each interview. This phase included memoing, where researchers documented initial impressions, notable quotes, and emerging patterns. Then, open coding was conducted, and the initial codes were generated in vivo where possible, using participants' own language to remain grounded in the data. After the initial round of coding, the team met to compare, discuss and refine the codes. This process ultimately resulted in the development of 11 unique codes, which were then organized into four overarching categories: 1) content difficulties, 2) course-based difficulties, 3) personal struggles, and 4) environmental struggles that vary from person to person. Table 2 provides the final codebook, including definitions and prevalence in the data set.

Table 2: Final Codebook

Themes	**Code** Engineering is difficult because of...	**Description** Participants experienced difficulty because...	**No. Participants (**Out of 21)
Content difficulty	Challenging course content	The material being taught is inherently challenging and can be difficult to understand.	17
Course-based difficulty	Course load balance	Courses are often designed with heavy workloads, considering students typically take 4-5 classes at a time.	14
	Course structure	Professors often use outdated methods or fixed structures, like a single exam, no flexibility, or assessments that don't match the course content.	13
Personal struggles	Time management	Considering the heavy workload, students often struggle to manage deadlines and balance time across classes, leading to last-minute cramming before exams.	13
	Work-life-school balance	Students often struggle to balance personal responsibilities, having to work side jobs, attend organizations, care for family, etc.	9
	Lack of study skills	Little to no knowledge of how to study efficiently for exams	7
	Mental health challenges	The workload, competitive culture, and difficult content can often trigger existing anxiety or self-doubt among students.	14
Environ-mental struggles	Professor personality	Professors tend to be less empathetic toward students and more focused on their own research than on teaching, which can lead to poor student-faculty relationships.	13
	Gendered experiences	Class environments are often male dominated, where women report being talked down to, leading to feelings of isolation and unwelcomed.	15
	Competitive, high-stress culture	The stereotypical engineering environment is highly competitive, where students are expected to be naturally 'smart' and are often met with remarks like 'good luck surviving engineering.'	6
	Lack of peer support	Keeping engineering culture in mind, individuals often find themselves struggling to find help or someone to relate with	13

IV. Findings

Our goal is to develop a framework that captures the different types of difficulty undergraduate students might experience in engineering programs. While not every student will experience all forms of difficulty, or face them simultaneously, our goal is to identify and categorize all potential difficulties. This framework is intended to enable conversations about which forms of difficulty are necessary for the learning process and which can be avoided. Based on our thematic analysis, we identified 11 codes that clustered into four overarching themes. These themes reflect the primary sources of perceived difficulty in engineering and are summarized in Figure 1.

In Figure 1, the student is placed at the center, surrounded by concentric rings that symbolize increasing layers of pressure. At the core lies the inherent difficulty of engineering content, which serves as a baseline difficulty for all students due to its complexity. Surrounding this layer are course-based difficulties, such as rigid course structures and heavy workloads, which further increases the academic strain. Adding onto the pressure are personal struggles, which vary widely among individuals. These may include balancing part-time jobs, involvement in multiple student organizations, or managing family responsibilities. The outermost ring represents environmental struggles, such as negative peer environment or the pervasive culture in engineering of cramming and pulling ‘all-nighters’, which hinder both one’s ability to learn effectively and well-being. Altogether, the layers illustrate the cumulative pressure that engineering students often face as they navigate their academic journey. Perhaps most importantly, this figure demonstrates that not all students will face the same challenges, and the “pressure” that one student experiences from each ring may be more than another.

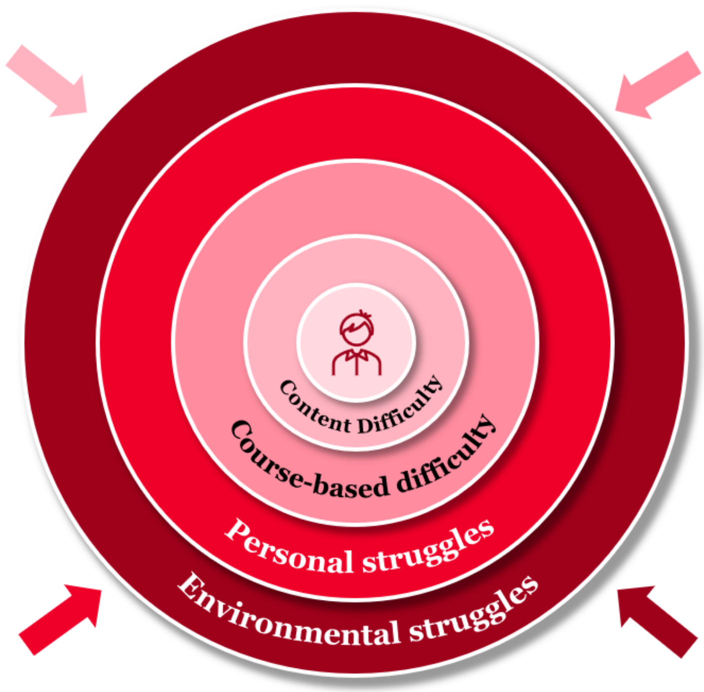

Figure 1: Characterizing Difficulty in Engineering as Concentric Rings of Pressure

Content difficulty. Known to be challenging, the content difficulty theme highlights the struggles students face when learning the material. These challenges originate from the complexity of the content itself, rather than from external factors. This difficulty might involve having a hard time understanding statics or struggling to complete thermodynamics work. For example, Ben emphasized the difficulty of taking calculus, saying, *"...especially calculus, calculus is so hard."* Isabella shared, *"I think it's just kind of a hard topic, because engineering does have to be rigorous to a certain extent."* These perspectives emphasize that the demanding nature of engineering content itself often presents a significant challenge for students, and that students expect to face this challenge.

Building on the difficulty that engineering students experience in their courses, a vast majority of participants shared their experiences involving many of their peers failing, either an exam or a class, because of how difficult it was. In addition to struggling to understand the material, participants also mentioned a lack of support from teaching staff. For instance, Alex shared:

> *It was really hard, and we didn't have enough TAs to help, and I think it was too much to be doing for that one assignment...I think the statistics show that 70% of my class was failing at that point.*

Together, these challenges amplify the already demanding nature of the coursework, creating additional barriers such as high failure rates, difficulty accessing help, and increased levels of stress among students. Introducing a metaphor, Isabella talked about how all incoming students eventually hit their first wall when they begin taking their first difficult course, such as calculus. Through this process, students are introduced to just how challenging engineering courses can be:

> *I just think it's a totally different way of thinking. And also just, you know, every engineer I think reaches a certain point where no matter how intelligent you are, you're gonna have to understand things and the concepts we're learning. So, I think just that first kind of wall you initially hit is challenging.*

After encountering their first wall, students can be discouraged from continuing their engineering education. These accumulated struggles consistently trace back to the general difficulty of the coursework itself.

Course-based difficulty. Diving deeper into course structure, the theme of course-based difficulty highlights the challenges students face that go beyond the content itself. These challenges often come from how courses are organized and the amount of work assigned. A significant issue lies in the variability of course structure across different professors, which contributes to student frustration and inconsistency in learning experiences. Participants shared their experiences in poorly designed course structures, such as having only one exam for the entire semester or assessments that fail to reflect content that is taught in the classroom. For example, Angel expressed this frustration, stating, "*It's sometimes a little frustrating because I'm like you never taught that in class. Why is it on the homework?"* Acknowledging this misalignment in course structure brings awareness to the barrier that hinders students' ability to retain course material effectively.
Participants also highlighted the importance of accommodating preferred learning approaches through varied teaching strategies. For example, Anna highlighted the value of visual aids in her learning:

> *I think having more visual aids or posting slides [can help]...my physics professor recently switched to putting more things on the slide and solving problems on the slide, which is really helpful. Because when I'm doing homework, I can look back through examples.*

Students perceived that professors did not consider the different ways students learn new material, which left many students without the support they need to succeed. In addition to course design, students frequently expressed concern over the volume of work assigned across multiple classes. Most students are enrolled in four to five courses per semester, and the cumulative workload could become overwhelming. Anna described this frustration:

> *I definitely think the time demands and just that high analytical thinking has definitely just mentally exhausted me. You know, as I'm advancing in coursework, that I'm just absolutely drained. It's one thing to have to write, you know, four papers in a week and that's tiring. But having to access not only you know, in physics, it's like, I use all of these physics equations for this. And then calculus I use all these calculus equations for this. And sometimes there's overlap, but it just feels like you're pulling from a lot of different filing cabinets.*

Many participants emphasized the need for professors to show greater empathy and understanding of students' broader academic responsibilities, advocating for more balanced and considerate course planning.

Personal struggles. We identified a level of struggle that does not necessarily arise from workloads or course structures alone. The theme of personal struggles refers to difficulties that are unique to every individual. Some participants mentioned working multiple part-time jobs in addition to being full-time students, just to afford tuition and living expenses. Others described the pressure to stay involved in numerous student organizations to gain experience for future opportunities such as internships. For example, Lauren shared:

> *I'm in a lot of clubs, like eight different clubs, and I work three part time jobs. So I have like no free time. I don't get a lot of sleep sometimes but I just kind of have to do my best to prioritize and multitask to get things done in time.*

Phillip also mentioned, *"I'm currently juggling my clubs, classes, and two other jobs. It's stressful."* This kind of overloaded schedule often results in poor self-care, increased stress, and poor overall academic performance.

With multiple responsibilities come multiple deadlines to manage and effectively complete. Proper time management was another large personal concern expressed among our participants. Lauren reflected, *"There's just a lot of moments like that where engineers procrastinate, and then we have to panic and pull all-nighters to pull off a project."* To add on, Olivia shared *"I always felt like I was kind of cramming my assignments."* These participant perspectives reveal the heavy toll that personal responsibilities can take on students' well-being and highlight the need for greater support systems that address the challenges beyond the classroom.

Environmental struggles. Focusing on the learning environment and the type of support students receive, the environmental theme highlights engineering culture, classroom dynamics, and peer support. In our study, women participants expressed feeling discouraged due to the lack of gender diversity in their classes. For example, Anna shared, *"As a woman, there's definitely been times that I've looked up and there are six women in this class of 40 students."* Reflecting on her experience with a professor, she added:

> *[There have been] times where I felt like if a woman brought up a question or an issue, it wasn't as if the professor didn't fully understand the question the first time, he didn't try as hard versus if a male student probably asked a similar confusing question.*

This example reflects the bias women can face when interacting with professors, who may show a preference for male students, reinforcing a discouraging and male-dominated environment. In addition to being a male-dominated field, engineering culture is often described as isolating [2], emphasizing that success depends solely on being smart and determined enough to make it on your own, enabling a 'sink or swim' mentality. This competitive environment can leave students feeling unmotivated and unsupported in their studies. For example, Angel shared:

> *Sometimes, I don't know if a lot of my peers do it intentionally or not, but they have a way of like, bringing you down, and I'm just like, it's really unnecessary. This is not a competition, we are all here fighting for the exact same degree.*

Such experiences highlight how the culture of competition in engineering not only creates barriers to collaboration but also contributes to a sense of isolation among students.

Another major concern expressed by participants was the impact professors had on their learning environment. Apart from the differences in how each professor structures their courses, students noted that professors also vary widely in their intentions and level of engagement. Often, participants felt that some professors prioritized their research over teaching and showed little interest in supporting students. For example, Lauren stated, *"...you can tell a lot of professors don't care, they're just there to do research. They don't care about the students in their class."* This lack of interest is often reflected in the professor's limited availability, such as not offering office hours or failing to provide extra support for students. Participants also reported challenges originating from professors' personalities and their lack of empathy towards students' workloads. This issue is also linked to the challenges that underrepresented groups face. Some professors fail to treat women or people of color the same way they treat a 'typical engineer' which is typically portrayed as a white cisman.

V. Limitations

An important limitation of this study is that it was conducted using a sample of 21 students from a single university. As a result, these findings may not be fully applicable to other institutions. Variations in university culture, student demographics, and the structure of specific engineering programs may influence how students experience and perceive difficulty.

VI. Discussion and Implications for Practice

Prior research has consistently highlighted the challenges students face when transitioning from high school to college, especially those entering engineering programs [3], [4], [5]. Students frequently report feelings of exclusion, describing the lack of sense of belonging, competitive environments, and the 'weed out' culture [3], [4], [5]. Similarly, participants in our study shared concerns about the lack of gender diversity within engineering, inconsistent course structures, and struggles with time management. While higher education is designed to be academically challenging, factors such as highly-sequenced course structures, heavy workloads, and the overall engineering culture have shown to intensify students' struggles, causing high failure and attrition rates [5]. However, through the process of learning new material, we posit that there are necessary and unnecessary difficulties that students encounter.

To better support student success, professors are encouraged to adopt a more empathetic and inclusive approach to teaching, including designing courses that accommodate diverse learning approaches and providing additional support through office hours and other academic resources. A few considerable examples for integration into the classroom are the flipped classroom strategy, where lectures are replaced by short, pre-recorded lecture videos and lecture classes are reserved for interactive activities and detailed discussions [16]. The hybrid teaching approach, where digital media and technology are integrated into the classroom could also bolster students' learning [16]. These approaches can help students feel more supported in their learning and feel welcomed into the classroom. On the student side, learning strong time management skills, seeking help when needed, and fostering a supportive peer environment can significantly improve both individual success and community well-being. Through these student efforts, the typical engineering culture of cramming information last minute and having to do 'all-nighters' can be minimized and less normalized. These strategies aim to support the unnecessary difficulties in engineering education, such as inconsistent teaching, limited support, and negative peer environment overall. However, it is important to acknowledge that the complexity of engineering coursework is a necessary difficulty. The challenge of the curriculum is designed to prepare students for the demands of the profession and ensure they are equipped to meet the needs of society.

VII. Conclusion

This study provided an opportunity to highlight the daily struggles students face in undergraduate engineering education. While the complexity of course content is an expected and necessary difficulty, factors such as negative peer environments and inconsistent course structures emerged as unnecessary difficulties. Through participant interviews, we were able to get firsthand perspectives, supporting our claims of various difficulties.

Our data resulted in 11 unique codes that were grouped into four overarching themes: content difficulty, course-based difficulty, environmental struggles, and personal struggles. However, not all students will experience all forms of difficulty, nor will they experience them in the same way, helping explain why students respond differently to the same environment. For instance, while one student may struggle in finding tutoring support for statics, another might struggle more with managing coursework alongside two part-time jobs. Nonetheless, nearly all engineering students experience at least one of the difficulties grouped within the four themes, each of which can impact their ability to perform at their best and progress toward earning an engineering degree.

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