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Investigating Engineering Culture During COVID-19

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Investigating Dimensions of Engineering Culture During COVID-19

Abstract

Research on engineering culture often aims, either explicitly or implicitly, to understand why engineering in the U.S. remains largely white and largely male. However, while increasing diversity in engineering has been a major focus in the U.S. for decades, the percentages for women and people of color have stayed relatively stagnant. Recently, however, the COVID-19 pandemic caused rapid changes in education and exacerbated challenges around diversity and inclusion in engineering. It also provides a unique opportunity to investigate engineering culture during a time of crisis to examine possibilities for cultural change from a new lens. To that end, this study investigates three U.S. mechanical engineering student's perspective on their department's response to COVID-19 in order to understand the extent to which various dimensions of engineering culture [1] impacted the response. This study aims to understand how students' reported experiences map onto the dimensions of engineering culture as well as to assess the fit of the theoretical framework and inform codebook development for a larger research study.

Introduction

Increasing diversity in engineering has been a major focus in the U.S. for decades. Significant resources have been invested in improving diversity in engineering, but the numbers have stayed relatively stagnant. Research on engineering culture suggests that we must look inside the engineering classroom in order to understand why engineering in the U.S. remains largely white and largely male [2], [3]. In order to successfully increase diversity in engineering in a sustainable and ethical way, we must not only examine but work to change the culture of engineering. However, the COVID-19 pandemic has exacerbated challenges around diversity and inclusion in engineering, but also provided an opportunity to either challenge or uphold the dimensions of engineering culture as courses and programs underwent rapid change. Many students face more barriers than before as they juggle COVID-induced challenges with their education, while others found increase access and lower stress. As part of a larger study, this paper examines three students' experiences taking mechanical engineering courses during the pandemic; the analysis serves as a pilot study for a larger research project that encompasses interviews with 23 students across two universities in the U.S. and South Africa. As part of the pilot, this paper assesses the value of an a priori codebook based on six previously identified dimensions of engineering culture [1], which serve as the framework for this study, as a means to understand what is entrenched and what is malleable.

Literature Review

Research on engineering culture has explored its values, beliefs, and underlying ideologies of the culture (e.g., meritocracy, rigor, depoliticization, technical/social dualism), showing us the ways in which this culture is exclusive of students from underrepresented minority groups [3]–[5]. Godfrey and Parker [1] mapped the cultural landscape of engineering education and developed a framework of engineering culture with six dimensions. Cech [6] described a culture of disengagement in engineering education and defined three underlying ideological pillars to this culture of disengagement. These ideological pillars have been identified by other scholars and found to be pervasive in engineering culture [5], [7]–[9]. Although much of this research into engineering culture has aimed to increase equity by sparking large-scale changes, the culture has proved highly resistant to such change.

Importantly, what we know about engineering culture was captured predominantly during periods of stability – that is, outside the kind of disruption seen in 2020 resulting from a global disaster, compounded by social unrest and economic turmoil. Yet research on disasters shows us that extreme events, like COVID-19, can reveal a culture's core beliefs and values, helping to illuminate underlying structural challenges and inequalities [10], [11] – structures and beliefs that are not necessarily apparent otherwise. For example, in response to an extreme event in South Africa (widespread student protests) that led to campus closures in 2016, faculty members reflected on their core beliefs about education and their ethical considerations around how to continue teaching during an event designed to disrupt the educational enterprise [11]. The COVID-19 pandemic thus provides an opportunity to investigate dimensions of engineering culture during a crisis, which can open new avenues for conversations about equity and accessibility in engineering by identifying which aspects of culture are most and least amenable to change. In other words, disasters can help uncover 'what really matters' and potentially offer a new avenue for cultural change.

This paper and its larger research project aim to capture student experiences and reflections, in their own words, in order to understand how dimensions of engineering culture interacted with practices in engineering education during COVID-19. This research project will then allow for future work that examines whether the rapid changes in higher education due to COVID-19 prompted sustained change to engineering culture. To this end, this paper investigates the following research question: In what ways do students' experience taking mechanical engineering courses during COVID-19 align with Godfrey and Parker's [1] dimensions of engineering culture? In doing so, this paper aims to assess the fit of the theoretical framework and develop a refined codebook.

Theoretical Framework

Godfrey and Parker's [1] six dimensions of engineering culture serve as the theoretical framework for this study. Godfrey and Parker [1] conducted an ethnographic case study of a school of engineering at a large, research-based university in New Zealand in order to "develop a conceptual framework of cultural dimensions that had the potential to guide the understanding of culture in the context of engineering education" [1, p. 5]. They identified six cultural dimensions, which capture the values and cultural norms of engineering: an engineering way of thinking, an engineering way of doing, being an engineer, acceptance of difference, relationships, and relationship to the environment. These dimensions are defined in Table 1. In this study, the theoretical framework was used to develop the interview protocol and is used to provide a priori codes for qualitatively coding the interviews [12].

Table 1: Dimensions of Engineering Culture [1] and A priori Codebook

Dimension	**Definition**
An engineering way of thinking	The kinds of knowledge that are valued and the prevalent way of thinking within engineering
An engineering way of doing	Shared beliefs about how teaching and learning should be done within engineering
Being an Engineer	"Beliefs and assumptions around the attributes and qualities inherent in being an engineer" [1, p. 14]; engineering identity and enculturation into engineering
Acceptance of Difference	Issues of diversity and homogeneity in engineering; values and norms associated with the dominant group(s)
Relationships	Beliefs around the right way for people to relate to each other within engineering
Relationship to the Environment	How engineering education interacts with broader systems (i.e., university, higher education, engineering profession, national context)

Methods

This paper presents a single pilot case study, where a mechanical engineering department is a case and students are subunits of that case [13]. We draw on hour-long interviews with three mechanical engineering students at a U.S. university in the mid-Atlantic region. This university shifted all courses online in March 2020 in response to the COVID-19 pandemic, and participants in this pilot study were interviewed in May and June 2020.

Participants completed a screening survey prior to their interview, which asked them to list their courses taken in the Spring 2020 semester and rate their perceived level of difficulty in those courses (a four-point scale ranging from "It wasn't ideal, but I did fine" to "Honestly, it was pretty rough all around"). In their interviews, participants were asked to talk through what did and did not go well while taking courses remotely and their perceptions of their instructors' and the university's response. After completing an interview, participants were asked to take a short demographic survey, which asked how they identify their gender, race/ethnicity, internet access, disability status, other relevant identities, and year in school (in March 2020). All questions except year in school were free response, which allowed participants to self-describe their identities. For this paper, a subset of participants was selected such that it represents a range of gender, race/ethnicity, year in school, and perceived level of difficulty. Table 2 summarizes the demographic responses of the participants selected for this pilot study.

Table 2: Summary of Participant Demographics

Participant ID	**Gender Identity**	**Race/Ethnicity**	**Year in School (in March 2020)**	**Level of Difficulty**	**Internet Access**
1001M	Man	White	Third-Year	1 – It wasn't ideal, but I did fine.	High speed
1009W	Woman	Middle Eastern	First-Year	2 – It was a little tough, but overall I managed.	High speed, but occasional connectivity issues
1012W	Woman	White	Second-Year	4 – Honestly, it was pretty rough all around.	Had access, but faced challenges with connectivity

Godfrey and Parker's [1] dimensions of engineering culture (see Table 1) were used as an a priori framework to analyze the interview data. After an initial coding using the a priori categories, a secondary coding was conducted to further code quotes in each category [12]. The refined codebook that resulted from this secondary coding is shown in Table 3 [12]. This coding process serves as a check of how well the framework can be applied to the data, and the results here will inform codebook development and future data analysis.

Table 3: Refined Codebook

Category (A priori)	**Code (Emergent)**	**Definition**
An Engineering Way of Thinking	Practice-based	Presence of practice-based coursework; Valuing of practice-based coursework over theory-based coursework
	Visualization Tools	Presence of visualization tools in coursework; Valuing of visualization tools
	Writing	Presence of writing in coursework; Valuing of writing
An Engineering Way of Doing	Being a student	Beliefs about how students should learn and act in engineering; reflections on experiences as a student in engineering
	Hardness / Rigor / Quality	Beliefs about how hard or rigorous coursework should be and the desired quality of engineering courses
	How classes should be taught	Beliefs about how teaching should occur in engineering; beliefs about which pedagogies should be used in engineering

Table 3: Refined Codebook Continued

Category (A priori)	Code (Emergent)	Definition
Being an Engineer	Engineering Identity	Beliefs around identity as an engineer
	Hardness (related to identity)	Beliefs around hardness as it relates to the qualities of an engineer
	Mindset	Beliefs about the mindset needed to be an engineer (or to be an engineering student)
Acceptance of Difference	Access to Resources	Awareness of / Consideration for (or lack thereof) differences in access to resources (e.g., internet, time zones); accessibility concerns
	Gender	Awareness of / Consideration for (or lack thereof) differences associated with gender.
	Illness	Awareness of / Consideration for (or lack thereof) potential for illness in course structure and delivery
Relationships	Peers	Beliefs around the right way to relate to peers; Reflections about how the participant related to peers
	Instructors	Beliefs around the right way to relate to instructors; Reflections about how the participant related to instructors
Relationship to the Environment	Department	Observations about how a course or instructor interacts with the larger department
	Engineering Profession	Reflections about how their experience relates to the engineering profession
	University	Observations about how a course or instructor interacts with the larger university

Findings and Discussion

The a priori codebook, shown in Table 1, was used to code the three interviews. Table 4 shows the frequency at which each dimension appeared in each interview: *an engineering way of doing* was most common with 103 excerpts across all participants and *being an engineer* was least common with 11 excerpts across all participants. After the initial, a priori coding sorted the excerpts into the six dimensions of engineering culture, a secondary coding was conducted to identify emergent codes within each category. These emergent codes are defined in Table 3 and discussed in the following sections.

Table 4: Counts of Excerpts Coded as Each Category

Category *(A Priori Dimension)*	**Number of Excerpts**			
	Participant 1001M	*Participant 1012W*	*Participant 1009W*	**Total**
An Engineering Way of Thinking	8	3	1	12
An Engineering Way of Doing	58	25	20	103
Being an Engineer	8	0	3	11

Acceptance of Difference	3	14	3	20
Relationships	21	7	5	33
Relationship to the Environment	4	10	7	21
Total	102	59	39	200

An Engineering Way of Thinking

Three codes emerged related to *an engineering way of thinking*: practice-based, visualization tools, and writing. First, participants reflected on the importance of *practice-based* laboratory experiences in their engineering education. Students were not allowed to physically come into the laboratory because of public health guidelines and university restrictions, so instructors had to find alternatives. Some posted videos of themselves doing the experiments and students used those videos to write their reports, some sent students ‘at-home kits’, and some created schedules to allow subsets of students to physically access the laboratories. Participants largely agreed that they missed out on the practical aspect of their education because of the restrictions on laboratories.

The other two codes – visualizations tools and writing – only appeared in participant 1001M’s interview. He noted that the *writing* portion of his laboratory course became very important when the hands-on component went away. This theme of the importance of writing continued to emerge in participant 1001M’s interview and was intertwined with practice-based ways of thinking in engineering.

Lastly, participant 1001M reflected on the importance of *visualization tools* in learning engineering concepts. Prior to shutdowns, in one of his theory-based courses, the instructor often brought in demonstrations and physical visualization tools in order to help students better understand the concepts. He cited a lack of those visualization tools in the online lecture and discussed feeling like he was missing something as a result. This incident reflects a belief that visualization tools can aid in learning engineering concepts and make the concept seem more concrete, which relates to Godfrey and Parker’s [1] finding that valued knowledge is “knowledge that is relevant to real life” (p. 10).

Altogether, in terms of *an engineering way of thinking*, participants largely emphasized the importance of hands-on and practice-based experiences. Additionally, one participant discussed navigating the balance between practice-based knowledge and writing knowledge and emphasized the importance of visualization tools in learning certain concepts.

An Engineering Way of Doing

An engineering way of doing appeared most frequently across the interviews, and three related codes emerged: being a student; hardness, rigor, and quality; and how classes should be taught.

First, *being a student* captures participants' beliefs about how engineering students should act, including approaches to classes, as well as reflections about their experiences being an engineering student during the pandemic. Each participant reflected on their approach to classes during the pandemic. For example, participant 1001M described his work style as "get ahead, stay ahead" and did not feel his peers were putting in the same level of effort as him, reflecting participant 1001M's beliefs about how learning should be done within engineering as well as his perception that his peers were not meeting his expectations of how students should behave. On the other hand, participant 1009W discussed her approach to work as she tried to raise her GPA in order to qualify for internships and jobs. She reflected on how a reduction in distractions and other commitments helped her better focus on her schoolwork.

> Because we went online, I had no big distractions. In regular life you have school, but you also have your social life and you just like do things. So once all those other aspects were eliminated— and looking back, it really, really sucked at the time because all I was doing was school. […] It was such a boring life, *but I ended up getting a lot better grades, because I was just studying*. Because there was nothing else to do. We were just in our houses all day. *[emphasis added]*

Where participant 1001M reflected more on his beliefs about how students should behave, participant 1009W reflected more on her experience approaching her engineering courses during the pandemic. Both students reflected a belief that engineering is hard and thus students should take focused approaches in order to succeed.

Next, *how classes should be taught* captures participants' reflections about course structures, pedagogy, and which approaches did and did not work well in the virtual environment. For example, participants 1009W and 1012W reflected on different approaches to teaching virtually, like asynchronous vs. synchronous approaches and different uses of technology to facilitate lectures. Participant 1009W noted that her spring 2020 courses were nearly all asynchronous, and at the time, she would have preferred synchronous meetings. However, when most of her fall 2020 courses were synchronous, she noted that she did not find them to be that helpful. This discussion of course structure also connects to *being a student*; participant 1009W went on to say that her synchronous courses were less helpful because she was juggling more responsibilities in the fall as "the world opened back up" and she was able to socialize, socially distant.

Where participants 1009W and 1012W discussed course format in terms of juggling their coursework, participant 1001M discussed course format in terms of structure and consistency. Participant 1001M preferred lectures and pre-recorded videos "stuck to the point" and emphasized his appreciation of clear, consistent communication. He reflected on one class where assignments were released sporadically and communication was sparse, but students were still expected to meet tight deadlines. Participant 1001M empathized with the instructor but ultimately wanted more structure and consistency. These incidents reflect participant 1001M's beliefs that instructors should be focused and direct in their lectures, have clear expectations, and clearly communicate their expectations to students. All three participants emphasized their appreciation of having lecture videos and lecture notes available after the lecture and noted that they hoped that practice would continue after the pandemic.

Third, *hardness, rigor, and quality* captures perceptions of instructors' expectations about maintaining quality and rigor through the pandemic, experiences of exam-taking, and perceptions of cheating. Participants described experiencing an increased workload in some of their courses. For example, participant 1012W reflected on courses where the workload increased as classes shifted online:

> I had instructors that were posting two-hour lectures for a 50 minute long like class, and then expecting us to watch those like three times a week, like it was just a normal class. So, it did feel like it got a little unrealistic at times. I feel like I spent every waking moment on my computer, just doing homework and trying to keep up with everything that was being thrown at us.

Here, participant 1012W's experience reflects a belief in *hardness* – engineering classes should be hard and time-consuming. Participant 1001M described a similar experience where the instructor chose to make the quizzes and exams harder because students were at home and the instructor couldn't proctor the exam as he typically would. These incidents reflect a valuing of *hardness* and *rigor*: courses and assessments must be sufficiently hard in order to assess students' knowledge.

Further, participant 1001M reflected on the overall impact of the shift to remote learning on the *quality* of his education:

> Now, in terms of proper learning of content, I think for some classes, it certainly took a little bit of a hit. But considering the circumstances, I think almost all of my instructors did what they could to accommodate. So, *it's more of a quality thing*, if you will. And I understand that almost everyone, I think, is not getting quite the quality they had prior. But I will say that I think the instructors are doing what they can. *[emphasis added]*

This incident reflects a belief that quality is synonymous with covering large volumes of content as well as a belief that quality is important in an engineering education. To this point, participant 1001M reported being thankful that one of his instructors did not remove content from the course, despite losing a week of class time during the March 2020 transition: "Even though the class was compressed, I'm glad he didn't remove any content. I think he didn't remove any content because *I think all of it was crucial*." *[emphasis added]*

Adding to concerns about hardness, rigor, and quality are concerns of cheating. While the participants understood the concern of cheating and could report stories of peers using unauthorized resources, participants discussed disliking measures that attempted to surveil students, like software that locks down the testing environment, recording students and tracking eye movement. For example, participant 1012W reflected on using a lockdown software and worrying that she would be flagged for cheating for "ducking down to type stuff into [her] calculator." She went on to reflect on an instructor that told her class that they "needed to have our whole selves visible and whatever we need to do—if we need to buy a new computer or buy a new, better webcam." She raised concerns about assumptions being made about students' access to resources:

> For them just to make the assumption that you have the resources to do things like that, and that you have everything that you need, like having like your mic on to take a test on those like lockdown browsers, like what do you feel a little sibling runs in there and you're living at home? Like, that's gonna trip you off? Congratulations. You just got flagged for cheating. Like, there's just so much more stress that all this technology that they're adding into the equation does is it's just not reflected when you're sitting—
>
> I mean, don't get me wrong, taking a test in person is stressful. But if your instructor sat hovering over you staring down at you the whole time and kept asking you, are you cheating? Are you cheating? Are you cheating? throughout the exam, I wouldn't get as much done. It's stressful. It freaks you out. So that's what it feels like. I think to a lot of students. I mean it's this constantly questioning, your integrity. So that definitely adds like whole layers to things that just aren't there when you do in class in person.

Altogether, participants reflections on their approaches to being a student and their experiences in courses reveal underlying beliefs about how classes should be taught, how students should behave, and how rigor and quality should be navigated in times of crisis. These subcodes also appeared in Godfrey and Parker's [1] findings about *an engineering way of doing.*

Being an Engineer

Three codes emerged related to *being an engineer*: engineering identity, mindset, and hardness (as related to the qualities of an engineer). Participant 1001M talked the most about *being an* engineer, and most of his excerpts related to one critical incident that encompassed both *mindset* and *hardness*: his experience in a particularly challenging course. Participant 1001M "naturally enjoyed the class and enjoyed the concepts" so he put a "lot of time into reading the book and into looking at some real-world applications." Because he enjoyed the class, it was easy for him to spend time on it, but he did not see that time investment pay off in the exams. He discussed feeling frustrated that he did not do well on the exams despite feeling like he really understood the content. He had to take on a specific mindset to make it through the course: deciding to focus on what he was learning rather than on his grades. This incident reflects participant 1001M's developing identity as an engineer – his exam scores did not reflect his understanding of nor his passion for the material. As a result, he took on the mindset that the 'hardness' of the course was good for him. While talking about a separate course, participant 1001M talked about taking on a similar mindset of "continuous improvement" in order to avoid getting overwhelmed by "monstrous assignments."

On the other hand, participant 1009W reported missing out on experiences she felt she needed in order to grow as an engineer. She was counting on practice-based courses in her third-year to help her decide what kind of mechanical engineering work she wants to do. But, with virtual learning and the shifting format of many laboratory courses, she felt she was "missing out" on that opportunity to explore her interests in mechanical engineering.

Participant 1001M's experience align with one of Godfrey and Parker's [1] descriptions of what *being an engineer* entails: Engineers are expected to be tough and self-reliant, which participant 1001M demonstrates in his response to his challenging course. Participant 1009W's experience aligns with *an engineering way of thinking* – practical knowledge is valued, and when she missed out on that practical experience, she had trouble figuring out what kind of work she wanted to pursue.

Acceptance of Difference

Three codes emerged related to *acceptance of difference*: access to resources, gender, and illness. In this section, *acceptance of difference* includes awareness of difference; if participants recognized that they or others may face challenges because of a difference, then that excerpt was coded as *acceptance of difference*.

First, participants discussed concerns about access to resources, either on their part or the part of other students. Participant 1012W reflected on her own access to resources, noting that in a virtual environment, not everyone is on the same "playing field":

> I think one thing that like, isn't always like realized is when you walk into a classroom, you have a pretty even playing field, like everybody has the same ability to learn. [..] But now with that many kids in one apartment trying to get on classes, I mean, my internet goes down like once a week. And I can't do it hardly anything on my computer if one of my roommates is on Zoom. None of this, like infrastructure was built to have this many people online. *Instructors don't always think about that.* […] Like it's not an even playing field anymore. It's really a question of, what resources do you have? Do you have a desk to work at? *[emphasis added]*

Participant 1009W mentioned one transportation-related instance of struggling to access resources herself, and participant 1001M did not discuss struggling to access resources himself. However, while not all participants faced challenges in their own experience, they did all identified challenges other students might face, like transportation challenges, access to Wi-Fi, and time-zone challenges. For example, participant 1001M reflected on an instructor who was "nice to us," accommodating students in different time zones by posting lecture notes on the learning management system. These incidents again show that participants were aware that other students may face more or different challenges than them.

Second, participant 1012W reflected on her experience as a woman in engineering, and noted that her experience got worse in the virtual environment:

> Being a woman in engineering – I've had instructors make comments about that. And sometimes you feel a little singled out. I think that's something that's gotten worse with being online. That's just kind of the nature of the field, I guess, as unfortunate as that is. You know, you deal with it.

She went on to detail the kinds of gendered comments that were made, including false assumptions and inappropriate comments. Further details are omitted to maintain participant anonymity. Participant 1012W was the only participant to discuss gender related challenges, and her experience highlights that engineering remains male-dominated, which can influence the cultural norms in engineering.

Third, participants 1012W and 1001M reflected on a need to better account for *illness* in course planning. Participant 1012W described taking an in-person exam during her first year with a 102-degree fever because "the instructors wouldn't be like, Oh, you have a fever? Like, go ahead and take the test tomorrow." She hopes that coming out of this pandemic, there will be more understanding around illness:

> It would be nice if coming out of this pandemic, people would be more understanding about allowing people to take time for their health sometimes. Give them the time that they need, don't force them in anything. It would be nice if we came out of here with instructors, you know, maybe being a little bit more sympathetic.

Notably, *acceptance of difference* is defined by Godfrey and Parker [1] as focused on acceptance (or lack thereof) of racial and gender differences. Themes related to race did not emerge in any of the interviews and themes related to gender only emerged in one interview. Moreover, it's important to note in response to participant 1012W's comments about a level playing field that the playing field was not level for all students before the pandemic [14]–[16].

Relationships

Two types of *relationships* emerged from participants' interviews: instructors and peers. First, participants described their interactions with their instructors, more frequently reflecting on how the instructor interacted with the class than how the instructor interacted with them individually. For example, participants 1009W and 1012W both emphasized that an individual instructor's approach to teaching virtually could have a large impact on their success. In this excerpt, participant 1012W reflected on her instructors' different approaches to the transition to remote learning in March 2020:

> My instructors that really felt like they were there to teach definitely were worried about keeping us on track and getting the material done. … Some of them were really worried about keeping us ready and keeping us in the zone and keeping us motivated and knowing that they were trying. Some instructors were probably scrambling. I don't want to be too hard on them. Because I mean, they had a lot to figure out too. And then some other instructors just kind of gave up. Maybe they just kind of showed up and figured out what was going on and went with it.

As exhibited in this excerpt, participants were largely empathetic towards their instructors, recognizing that everyone was facing challenges. However, participants still found it frustrating when they felt instructors were not communicating with them.

Second, participants described how they related to their peers. Participants 1012W and 1001M expressed some frustration with their peers. For example, participant 1012W reported knowing that some of her peers were using various unauthorized resources to cheat on exams, which was frustrating to her:

> I'm not going to cheat. I hold myself to a high standard. […] But if you have half our class cheating, it might make me look bad as somebody who doesn't cheat, if now I'm below average and I don't have as high of a class rank.

Moreover, participants 1009W and 1001M reflected on how collaborating with peers changed due to the pandemic. For example, participant 1009W was thankful that she formed connections in her Spring 2020 courses before shifting online and anticipated younger students were facing challenges forming those bonds with peers. On the other hand, participant 1001M reflected on helping his peers with their shared courses: "I helped out a lot of my friends who either didn't understand or procrastinated a little bit with it. And I had to teach everything to them."

These findings suggest the importance of instructor interactions to student success – participants reported being more successful and less frustrated in courses where instructors were communicative and understanding. Additionally, these findings support Godfrey and Parker's [1] finding that friendships were important for students' success in engineering and raises concerns for those who were unable to form peer relationships virtually.

Relationship to the Environment

Three levels of *relationship to the environment* emerged from participant's interview: department, engineering profession, and university. First, participants reflected on their department's approach to the transition to online learning, noting instances where their instructors leaned on departmental resources to aid in the transition. Additionally, two participants reflected on challenges they faced with the rigidity of the department's policies (e.g., course substitutions and progress policies).

Second, participants 1009W and 1012W discussed how their experiences related to the engineering profession in terms of finding a job and preparation. Participant 1009W expressed concerns about finding a job and noted that the company she interned with was not hiring because of the pandemic. Participant 1012W discussed broader concerns about finding a job, worrying about how her degree would be viewed by the engineering profession if some of her peers were cheating. Finally, participant 1012W noted that she does not expect working remotely during this portion of her education to prepare her for work as much as others might expect.

Third, participants reflected on their university's response to the pandemic and how university-level factors influenced their experiences in engineering. Each participant discussed university-factors differently. Participant 1001M discussed the university response in terms of what he observed in his classes; he recalled one instance of an instructor asking for university support during the transition. Participant 1009W felt that money and public safety were the biggest influences in the university's pandemic response, but generally felt the university responded well and was thankful that the university stayed open in Fall 2020 despite rising cases. Participant 1012W was the most critical of the university, wishing the university had done more to hold instructors accountable and expressing concerns about the quality of her degree.

Altogether, students noted instances where the department and university influenced their classroom-level experiences in engineering. Godfrey and Parker [1] found that the engineering programs they studied tended to prefer a 'go it alone' approach, though departments are subject to influence and regulations from their respective university and government. These findings suggest that departments were impacted by university-level and national policies enacted in response to the pandemic.

Conclusion and Future Work

While it is not possible to draw conclusions about engineering culture and inclusion based on the small sample size in the pilot study, the findings here do highlight a range of differences in both how these participants experienced engineering culture through the pandemic and what dimensions of that culture seemed most malleable and most resistant for these students.

Overall, the findings from this paper suggest that mechanical engineering student's experiences, as captured in this study, can be understood through the lens of the dimensions of engineering culture [1]. Participants discussed the importance of hands-on components of their education (*an engineering way of thinking*). They reflected on beliefs about how classes should be taught, how students should behave, and how hardness, rigor, and quality should be navigated during the pandemic (*an engineering way of doing*). They expressed their beliefs about the mindset needed to be engineer (*being an engineer*). They discussed challenges that they and others faced during the pandemic, demonstrating an awareness of the effects of difference in engineering (*acceptance of difference*). The participants described feeling empathy for and frustration from instructors and discussed collaborating with peers (*relationships)*. Finally, participants noted interactions their department and university as well as discussed concerns related to the engineering profession (*relationship to environment*).

Altogether, the six dimensions of engineering culture [1] are a suitable framework for these data. The data aligned with the dimensions and several codes were identified as subsets of each dimension. Moreover, many of the codes that emerged in the secondary coding aligned with Godfrey and Parker's [1] original findings, like the belief that engineers should be tough and self-reliant (*being an engineer*: mindset) and the beliefs about rigor and quality (*an engineering way of doing:* hardness, rigor, quality). These findings suggest that additional interviews conducted with a similar interview protocol can be analyzed using the same theoretical framework. Finally, while this is a small sample and should not be generalized, the findings highlight differences across genders as well as ways in which the underlying structures and assumptions of engineering are barriers to equity. More work across a wider sample is needed to understand the degree to which the patterns in this small data set reflect larger scale trends.

Future work will analyze 20 additional interviews, across two universities, as part of a comparative-case study and will build on the codebook development in this paper, applying the refined codebook to the additional interviews.

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