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Exploring Undergraduate Engineering Students' Understanding of Power Dynamics

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Introduction

Engineering education in the United States has grappled with the issue of representation from its inception, but in the last few decades, there has been a grand effort to improve diversity, equity, and inclusion in the field of engineering [1], in particular for minoritized students, or students from racial minority backgrounds. The goal of representation has been to have the demographics of students in our field be representative of the demographics of our nation. Yet, even though we have seen numbers fluctuate for different minoritized groups, either decreasing or slightly increasing, participation rates remain the same [2]. The engineering education community is shifting its focus beyond increasing numbers, to addressing inclusive environments at the systemic level. Having a diverse student body representative of the general population is a good thing. But creating an inclusive environment (a space where there is equitable access to resources and participation and all students experience a sense of belonging) is what will sustain the change of representation within the cultural norms of engineering that reproduce underrepresentation. When taking into consideration Kimberle Crenshaw's warning that "tokenistic, objectifying, voyeuristic inclusion is at least as disempowering as complete exclusion [3], as a community, we should acknowledge the harm we can reproduce if we do not implement inclusive practices with a critical lens.

In relation to looking at barriers to inclusion, studying the phenomenon of power in the sociological sense has also gained traction in engineering education. Moving in this direction is critical as we seek to understand barriers to diversity, equity, and inclusion. In this paper, we use the Oxford Dictionary definition of power: the capacity or ability to **direct or influence** the behavior of **others** or the **course of events**. Power as a phenomenon has become particularly important in understanding structural systems of oppression that prevent major change to happen in diversity, equity, and inclusion efforts. This paper looks to explore Patricia Hill Collins' framework of domains of power, in an effort to provide tools for the engineering education community to have nuanced conversations about this complex phenomenon of power or power relations. This framework provides insights into different levels of power relations. Engineering education researchers have already brought the phenomenon of power into the conversation. From a critical perspective, the community has published work about bringing power into the curriculum [4], how power is perpetuated in student feedback [5], and even as a tool to explore power dynamics within research teams [6]. Of course, the exploration and questioning of power is foundational to critical perspectives, such as Feminist perspectives, Critical Race Theory, and Critical Pedagogy. In this paper, we lay out characteristics of power, and discuss Collins' Domains of Power, as part of the theoretical lineage framework from which intersectionality develops from, and apply it as a lens to understand how engineering students characterize power in their environment.

We then use this framework to analyze themes in student's understanding of power in an Engineering education context. In the discussion, we explore how faculty might further use these frameworks in research and gaps that are revealed through the usage of these frameworks in practice. In having these conversations, we hope that the community can have more tools to name instances of power, either positive or negative, in their context in order to enact change.

In this paper, we ask: How are students conceptualizing their experiences of power and how does their conceptualization shift over the course of three co-design workshops? And how do these findings map to one influential framework for thinking about power, Patricia Hill Collins' framework of Domains of Power?

Related Work

Characterizing Power
Here, we assert the following characteristics of power. Power requires more than one actor, but those actors can be individuals, systems, or even inanimate objects— it is a relational phenomenon. In addition to this definition, power has been identified as something that can be exercised [7], possessed [8], or experienced. Power can be observed when one actor acts on another. Therefore, here we explore issues of power by looking at power relations, or examining how power affects interpersonal interactions. Power can also be analyzed from the perspective of the individual exercising it, or from the perspective of the individual experiencing it. Through the exercise of power, social and cultural norms (positive and negative ones) can be reproduced or disrupted. Additionally, power is inherently neutral but can be used either in a positive or negative manner. This conception of power is often difficult to embrace given that power tends to have a negative connotation, as related to dominating, oppressing, and violence [9]. But, power can also be a productive phenomenon, such as empowering, leading, and directing [8]. Because of the complexities of power, in addition to these characteristics, we introduce Collin's framework of Domains of Power to observe multiple levels of power.

Revisiting Intersectionality and Domains of Power [10]
Patrica Hill Collins' framework for intersectionality includes four different, yet interconnected domains of power. These domains include: structural, disciplinary, cultural, and interpersonal. This section will expand on the four different levels of Collin's framework. In this framework, race, gender, class and other identities are different axes of analysis within these different domains.

Interpersonal
In the interpersonal domain, "power relations are about people's lives, how people relate to one another, and who is advantaged or disadvantaged within social interactions." [cite] This can be

seen through the various -isms, sexism, racism, classism, etc. In our work, we use Kathryn Pauly Morgan's Identity Wheel to help students reflect on which identities they are bringing with them [cite]. At the interpersonal level, the intersectional makeup of one person places them in different locations within the matrix of domination, as the interplay of advantages and disadvantages of different identities are seen in how people interact with one another.

Cultural

In the cultural domain of power, "ideas matter in providing explanations for social inequality and fair play." These cultural norms include ideas about how to measure intelligence, what activities are considered intellectual, and what counts as science. In the cultural domain, we see some cultures valued over others, moving power dynamics beyond individual actors, to a larger social phenomenon. The cultural domain helps us describe how power can be understood in a particular context— specifically how one moment in time is affected by the context in which it is happening, and the historical moment in time it is happening. The cultural domain reminds us there is an element of time and situatedness relevant to power.
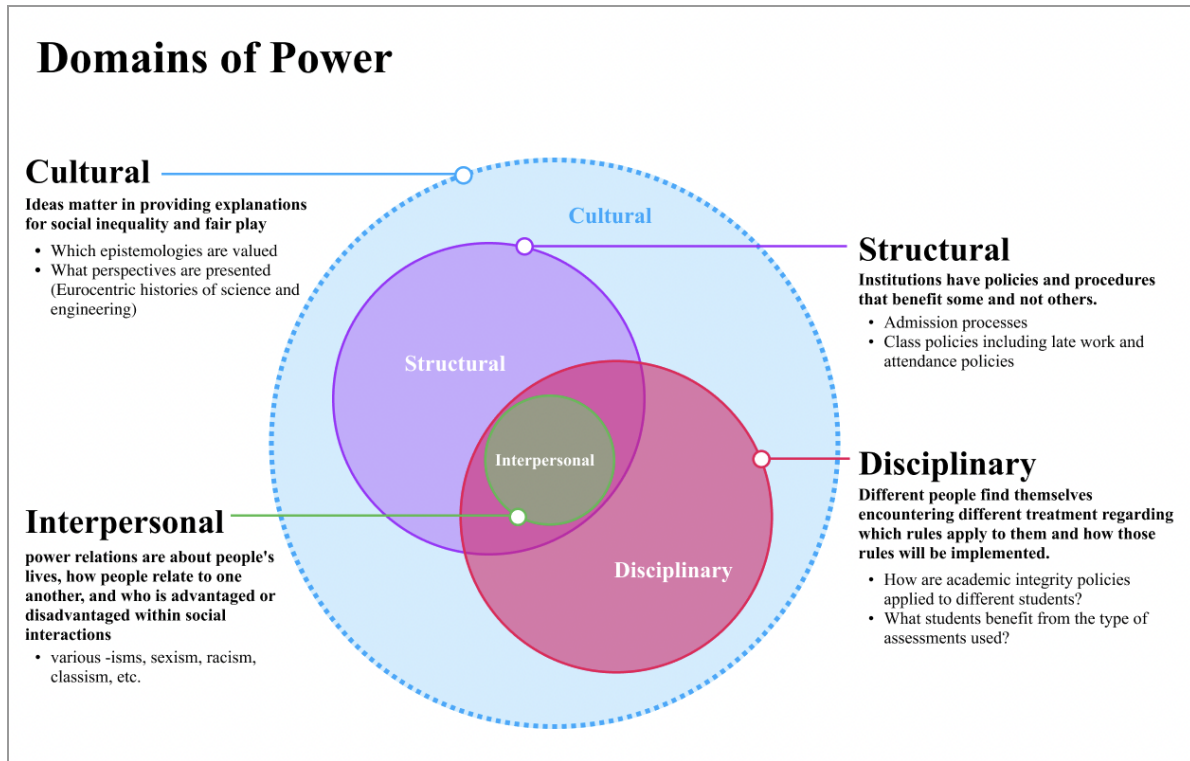
Disciplinary

In the disciplinary domain of power, "different people find themselves encountering different treatment regarding which rules apply to them and how those rules will be implemented." Within different contexts, whether it is at the institutional level, such as higher education, or at the level of a group of friends, there are different rules on how to behave, succeed, and interact. In engineering specifically, this can be seen in how traditionally, there have been lecture style courses where students are listening to learn, whereas in other disciplinary domains, like the humanities, discussions are a part of how the learning is done. Other discipline specific rules include how learning is measured, such as exams, projects, like in engineering or even a performance piece, such as in an art discipline.

Structural

In the structural domain, institutions have policies and procedures that benefit some and not others. In higher education, these policies and procedures include admissions processes and requirements, defined by the institution itself.

The structural domain of power is relevant as the engineering education community seeks to dismantle sites of oppression. But as we see here, it is one of many intertwined layers. This paper offers these frameworks as tools to do analysis within and across domains from the individual to the structural within engineering education. Figure 1 shows a representation of the interconnectedness of the domains of power and includes some examples relevant to engineering education.

Domains of Power

Cultural

Ideas matter in providing explanations for social inequality and fair play

- Which epistemologies are valued
- What perspectives are presented (Eurocentric histories of science and engineering)

Cultural

Structural

Institutions have policies and procedures that benefit some and not others.

- Admission processes
- Class policies including late work and attendance policies

Structural

Interpersonal

Interpersonal

power relations are about people's lives, how people relate to one another, and who is advantaged or disadvantaged within social interactions

- various -isms, sexism, racism, classism, etc.

Disciplinary

Different people find themselves encountering different treatment regarding which rules apply to them and how those rules will be implemented.

- How are academic integrity policies applied to different students?
- What students benefit from the type of assessments used?

Disciplinary

Figure 1: Domains of Power [representation with examples from an engineering education context

Vignette to Demonstrate Domains of Power

In this section, we share a fictional vignette inspired by stories heard throughout our research study to demonstrate how the domains of power are at play in the everyday lives of students and create barriers to success. Here, we present the story from the perspective of a student in the United States with multiple marginalized identities.

"Jamie is a Latina student in a first year engineering design class. She is working on a project in a team of four students, and she is the only student of color on the team. When sharing ideas for their design project, Jamie notices her ideas keep getting ignored in this *interpersonal* interaction. She begins to wonder if her ideas are truly valuable, or if she is not communicating them well. She does not want to cause a problem in case she is just imagining things. But these experiences make her wonder if engineering is even the right major for her. In engineering, where the *cultural* perspective is that a stereotypical student is white and male, students often have the unconscious bias that gives white, male students the benefit of the doubt, assuming they are smart and experienced. Socially, Black and brown women are stereotyped as angry or loud. Jamie's awareness of this stereotype makes her think twice about speaking up. Additionally, *disciplinary* power also makes her reconsider speaking up— engineering courses are built on teamwork. If

she were to speak up and was not supported by her peers because they did not notice anything happening, and her professor mentioned that she should just learn to deal with team dynamics, she could develop a reputation as a problem student that would impact the rest of her academic experience. Teamwork is also often evaluated by peer reviews, therefore, there can be direct consequences to her grades. Grades impact future opportunities as there are often minimum GPA requirements for internships and jobs, including faculty perspectives of her for letters of recommendations. Finally, given that she is in her first year at a large public university, she has not been accepted into her major yet. This *structural* manifestation of power also impacts the choices she makes in the scenario. In order to get into her major of choice, she needs to maintain a competitive GPA and a good relationship with faculty. She is coming from a low-resourced high school that did not offer AP classes, so she already feels behind many of her classmates, in terms of class standing based on credits."

In each of these examples of the domains of power, we see how interactions, ideas, rules, and procedures keep Jamie from acting and standing up for herself. She knows her actions have repercussions, but *in this one moment*, it would be difficult for any one person to name or even process the different levels of power that are contributing to inaction. And yet they do.

Methods
This paper reports on an ongoing study. The methods described here include the overall methods, but this paper only discusses the results of a subset of the data.

In order to gain an understanding of how current undergraduate engineering students and engineering faculty understand power and power dynamics, the research team developed a set of workshops for students and faculty to co-design inclusive practices while exploring their own identities with respect to power. Part of this study was exploring the possibility of consciousness raising for students and faculty in their understanding of power.

The participants were recruited from the College of Engineering at a large public university in the Pacific Northwest. Recruitment emails were sent to various mailing lists and students were recruited through large courses. The final set of participants included two faculty members, one graduate student who had served as an instructor of record and four undergraduate students. Five of the seven participants identified as female and two as male. Three identified as white, two as Asian and two as mixed race, both of whom identified as Asian as one of the two races. We aimed to recruit participants representative of the diversity within engineering along both the gender and race/ethnicity identities. We did not get a representative group of participants therefore, we will share more about how these demographics impacted the results in the discussion section. Student participants received $120 compensation after completing all sessions. Every participant received lunch during the co-design sessions.

The study was set up for participants to participate in three 90-minute co-design workshops. Participants also participated in 30 minute pre and post workshop semi-structured interviews, and were asked to submit a reflection prompt after each workshop. For this study, we are only looking at the interview transcripts and post-workshop reflections. Each interview was recorded on Zoom and the research team made sure the transcription matched what participants said in the interviews and then anonymized for analysis. The reflection responses were collected on Google Forms. The reflections were checked for anonymization.

With the data transcribed, the research team conducted preliminary qualitative analysis and clustered descriptions of power into themes using Patricia Hill Collins' Domains of Power as guidance. The preliminary themes are described in the following section. This is an ongoing analysis and the research team hopes to conduct more rigorous analysis on participants' understandings of power.

Positionality Statement
Here we address our positionalities as researchers, critical to reflexively acknowledging our stance as researchers. The first author conducted the interviews, ran the co-design sessions and analyzed the data [29]. She is a first generation Latina with a background in mechanical engineering. These identities impacted the research because in her own education, there were times where she connected to the material and enjoyed her learning experiences, and other times neither was true. The second and third authors joined the research team during the data analysis phase.

The second author is white and identifies as queer. They have an educational background in electrical engineering and computer science, and have spent several years in the industry as a software engineer. They have also spent several years organizing free learn-to-code workshops for people of marginalized genders. These identities and experiences were significant throughout the data analysis process because they allowed the author to call on their own understanding of engineering culture, inclusive learning environments, and how identity and privilege intersect with both.

The third author is a first generation college student that identifies as both Asian and white. She studied electrical and computer engineering and was actively involved in an organization that provides support and mentorship to historically underrepresented engineering students. Her background impacts the analysis of the data as she can relate to some of the data from her feelings and experiences within engineering spaces, and she is personally interested in fostering more inclusive and diverse learning environments.

Notably, all authors are now pursuing work outside of their "traditional" engineering disciplines. Throughout the data analysis process, all authors discussed and compared their own experiences with engineering education, how their own identities impacted their experiences, and how this helped them better contextualize the data.

Results

Several themes arose when looking at how participants discussed power and power dynamics. Participants noted that power dynamics required social interaction— that is more than one actor. Other themes revolved around participants talking about how they experienced power dynamics and how they used power themselves. Students also noted that participating in these co-design sessions discussing power led to more awareness of their own role in helping enact change. In the following sections, students will be referred to as S1, S2, S3, and S4, as in "Student 1" and so forth.

Experiencing Power Dynamics from Faculty

Before going through the workshops, students were able to identify different sites where power was visible. They talked about the engineering education space in general, faculty, and their own feelings of power and disempowerment. In particular, students made note of the largest power differential in a classroom: faculty and students. Participants generally felt that instructors are granted power and respect by default. S3 provided this relationship as the first example that came to mind when asked about the meaning of power dynamics,

> *"I think power dynamics is… there always has to be someone who has more power than the other person like, for example… especially in the classroom, I'd say a professor or a TA have more power over the students." (S3)*

S1 explained that because faculty inspire this kind of respect from students, they may be exhibiting power over students even when they're not aware of it,

> *"I think that especially when professors are speaking, or they're having a conversation or just interacting with another student, I think it's really critical that professors or faculty are aware of that power dynamic, especially in the way that they talk to students and communicate to students." (S1)*

S1 went on to discuss how this power was present during the co-design sessions, and how he noticed not only that faculty voices held more weight in the conversation, but also that he himself subconsciously gave more respect to faculty when they were speaking,

> *"I felt that this part of the conversation had power dynamics in the conversation, where the voices of faculty were weighted due to the nature of their position as well as their age. Students participated less in conversations, and I felt that it was harder to speak up in this conversation as well." (S1)*

> *"when I was talking to a participant that was faculty in the sessions, before the session started… I noticed myself just being much more attentive, being respectful, letting them finish, even if it wasn't something relevant or something that I didn't really want to talk about." (S1)*

In his continued discussion of this normalized respect for faculty, S1 goes on to say how the structure of educational systems have conditioned students to automatically understand and comply with an academic hierarchy,

> *"I think it's so normalized too, you know. Respect... upperclassmen, people that have done things that you want to do. Second, I guess. Then it would be like TAs or teaching staff. Then it would be like professors, you know all those, this chain or level of respect. I think it's so normalized in all of our academic and educational institutions. And I think that starts on a much deeper level than just college, you know. I think it starts from, you know, even preschool elementary school all the way throughout one's K-12 education." (S1)*

This long-standing association between instructors and power dynamics is further highlighted by S2, who, when asked to provide examples of problematic power dynamics in the classroom, shared an example dating back to elementary school,

> *"I had this teacher. People hated this teacher because she would have favorites, and even her favorites would be like, 'Yeah, this teacher is not a…very good teacher.' Thankfully, it was in, like, elementary school, so at least the grades didn't get impacted." (S2)*

S2 mentions the impact or power educator's have over grades, a theme that comes up throughout the sessions. Other student participants also highlighted the relationship between students and faculty when asked to discuss problematic power dynamics. Students cited examples of tolerating unpleasant or inappropriate behavior from faculty out of fear of retribution. S3 explained that in a class with a professor who would shut down student ideas, he chose not to contribute or ask questions to avoid being scolded,

> *"Most people didn't react too much, but you can... really tell they [students] kind of feared the professor... I kind of just didn't say anything or ask questions, because I*

[didn't] want to get.. into a whole like, not argument, but I just don't want to be scolded."
(S3)

When asked about the meaning of power dynamics, S1 suggested that one must factor in not only how we treat others but also how we allow ourselves to be treated,

> *"There's just a lot of different dynamics that come into play in terms of power, and not only in the way we treat others, but also in the way we allow ourselves to be treated. I think that's a big thing, and how we allow, you know, unspoken biases to kind of just play out on some occasions." (S1)*

and goes on to explain in the context of faculty,

> *"But where some of the students potentially might think with the professor, someone who does have power, they might not have the right even to speak up in fear of, you know, retribution of any like consequences and in that case I would say they allow [instances of bias] to take place." (S1)*

This student-faculty power dynamic is further complicated as students discuss their future engineering careers and the role faculty may play in securing their place in the field. As S4 explains, she hopes to leverage her connection with the professor she currently work with for future employment opportunities,

> *"I research with some of the mechanical engineering professors [and when] I'm, at the point of [needing to apply for jobs] I will leverage him and his sort of power in that research space, hopefully to get a job. But if… he's connected me with someone in industry to talk to… that kind of thing is definitely benefiting from that power dynamic." (S4)*

S1 makes this direct connection between a fear of faculty retribution and the importance of letters of recommendation, and how the knowledge of all the ways faculty might leverage their power in the engineering field could prevent students from speaking up,

> *"Students, I believe, are less likely to react, or even kind of speak up about that, especially as with power, you know, they [faculty] have control over… grades, outcomes… extensions… or other opportunities, recommendation letters. There's so many different aspects that you know, those that do have power in the engineering community have over others." (S1)*

Even though students highlight fraught power dynamics with faculty, they still empathized with them and valued the opportunity to hear their perspectives throughout the co-design sessions. As explained by S3,

> *"It is really nice to like, talk or like, listen, and hear what the faculty members have to say, because I feel like I don't really, it's almost very separate between students and, professors. It's really kind of unique to talk or interact and listen to what they have to say, especially when it's, outside of the classroom. It's kind of a different environment." (S3)*

S1 also empathized with and acknowledged the unique challenges of being an educator, but added that these challenges are not an excuse to abuse the power that inherently comes with the position,

> *"... being an educator, being a teacher is difficult. I've learned that too, it takes a lot of energy. Takes a lot of time, takes a lot of commitment, and it definitely takes a lot of, I want to just say your emotional energy…that should not be an excuse to treat anyone differently, to abuse that power dynamic. I think, no matter how much we try to enact change, they are still a professor teaching faculty, and we are students....There are so many factors that play into that power dynamic, and it can't just be erased even with the series of initiatives or actions." (S1)*

Consistent with the respect for faculty and in some cases a fear of retribution, students also noted that positive change around power dynamics and engineering culture has to come from faculty and those who already hold power,

> *"One interesting thing that we discussed was how older professors are a big problem since if they are unwilling to take part in improving power dynamics in the classroom, then little to no change will be seen." (S3)*

S4 also emphasized that faculty have to not only be "aware" of power dynamics and their impact but also "have to care that it's a thing" and "want to do something",

> *"And you've got a lot of faculty members who have a lot on their plate, kind of like we discussed, and who might be aware that it's an issue, and who might care but like it's not the priority." (S4)*

In addition to noting the problem of faculty who are not willing to make positive change, S3 thought about how different the conversation in the study would look if you had older, male faculty participating, a demographic that has the most privilege in engineering spaces,

> *"There were no older [male faculty] in this study. I think…you'd have a much different perspective of what they would think on their solutions, or maybe even they wouldn't consider…a lot of [these things] problems. They wouldn't see power dynamics as a possible problem in the classroom," (S3)*

S4 then imagined having to start the conversation about power dynamics during office hours and how others would not want to use that time for that,

> *"I don't even know what you would say if you want to talk about power dynamics in office hours, but I don't think that would go over particular, because everybody else would be like nah we…we need help with our homework." (S4)*

S4 also acknowledged multiple reasons faculty might not want to bring up conversations of power,

> *"...whatever it's going to sort of inhibit that, whether it's just prioritizing your time or feeling like the risk is too great if you bring it up. Um whether that's because you don't feel like you have power…" (S4)*

S1 also discussed the multiplicity of possible reasons change is slow to happen, pointing to institutional reasons and giving examples of things faculty have control over,

> *"There are tangible things that can be done within classrooms and in the community that just have so many legalistic or so many institutional blocks that prevent that from happening. Something as simple as adding things to a syllabus or restructuring how classes are done.... the implementation is hard." (S1)*

<u>Perceived Intelligence as Power in Group Projects</u>

When asked about power dynamics within engineering spaces, each of the student participants mentioned examples related to group projects whether for a class, lab, or extracurricular club. The majority of participants recognized that, in general, those who are viewed as more competent, knowledgeable, or experienced within these group settings can hold more power over those that do not. S2 started with talking about subject knowledge,

> *"I guess in general, if someone has more knowledge on the subject, or knows more than they do, then they generally will have more power over what is what the project is than you normally would have." (S2)*

Similarly, S1 talked about competency and doing more work,

"And also just the competency. I think those are really big things and just engineering as a whole. Um, definitely, those that do more work and have power over those that do less work, especially in a group or team setting." (S1)

S3 highlighted how underclassmen have less power when working with graduate students who not only have more experience than them but also have more ownership of the project,

"[As] an undergrad, working in the lab, the PhD and the master student are going to have way more power, I guess, than the undergrad student, and they rightfully should, because it's their project. And they have a lot more experience working in a lab environment." (S3)

Several participants discussed how students who are considered smart or competent can be seen or treated differently.

S4 mentioned how she thought that S2 would have more confidence since she was smart enough to come to university before graduating high school,

"I always expect the really young folks who are coming to [university] before graduating high school to have some kind of confidence based on the fact that they are smart enough to do that, like that's pretty incredible. But [S2] obviously didn't feel that way." (S4)

S1 discussed how there's several ways a student can be more competent than others and how these play into power dynamics of how students view and treat one another,

"I think another part in there is competency, whether a student is more competent than another, whether it's in their engineering, or even their own, English or verbal skills or their work ethic, you know. I think there are a lot of, power dynamics there in play where you know, peers can see things differently and treat others differently because of that as well." (S1)

S4 often mentioned how she needs to assert herself within group projects and convey that she is smart early on to prevent herself from having less power in these settings,

"If you don't set yourself up as, like, the smart one in the group, you're never going to get back to that. If you don't and initialize, like, this is who I am, you can have trouble with people giving that power back." (S4)

S4 also recognized that because of her greater experience, she can allow others in their group to do work that they may have more opportunities to do at another time,

> *"I was like, okay, I know the lab pretty well because it was through the same lab that I work in and was kind of willing to, like, take the back seat because I felt like I maybe had more opportunity to do that in the future." (S4)*

S1, S2, and S4 all mentioned how their groups in a project experience better dynamics and outcomes if students are able to work on things that they have interest in or play to their strengths. S1 specifically talked about learning to speak for himself in group projects,

> *"You know where I've done more work personally on a project and where I've done less work personally on a project, and whether that be my own choice because of my passions or lack of passion... I've definitely learned to speak up for myself over the years, and you know, ensure that you know things are fair and to everyone's own strength. You know that that's the best way to finish your project." (S1)*

S2 and S4 both discussed how team members would feel if they are allowed to choose what to work on and how that impacts the results of the project,

> *"But if you let people do the tasks that they really want, then they're gonna first of all, look up to you a lot more. But also they're gonna have a better time on the team, and they're gonna be able to DO things a lot better." (S2)*

> *"Because we were going to be spending a lot of time doing this stuff, and if people are interested in what they're doing, they're gonna have better results. They're going to be willing to spend more time... It's more fun to work with happy teammates." (S4)*

Belonging as Empowerment

Students talked about how they saw themselves feeling empowered or disempowered. This was a direct question asked by the research team. One male participant acknowledged the privilege that came from holding a male identity, but that it contributed to him feeling uncomfortable when talking about female representation in the engineering field,

> *"...when we're talking about female representation in STEM, and how men hold this huge power dynamic over women, I found it much more difficult to contribute to that conversation because, although I am a male, I'm not in that position of power, of leadership, or have that power to, you know, make those changes necessary." (S1)*

S4 shared that she felt empowered by sharing the same gender identity and experiences related to gender as the "more powerful individuals" in the room,

> *"Of my identities that impacted how I engaged in this session, gender was definitely the most salient…the faculty/teachers that were there during the discussion share my gender identity, and thus we share some of the examples of exclusion that surround that identity… Thus, the identity contributed to my feeling of empowerment both via being in a majority and sharing key disempowering experiences with the majority." (S4)*

S3, a male student, also noticed this feeling of empowerment among the women,

> *"I would have expected the females to say that they're more disempowered because of the general stereotype in terms of engineering classroom, but it's interesting to see that they felt empowered, which is a good thing, especially considering that there were more women than men in the study, and they felt more comfortable speaking and being a part of it, which is awesome." (S3)*

Similar to having shared identities and experiences, two of the other participants shared how feelings of belonging helped them feel empowered. S3 specifically talked about his newfound gratitude for being accepted in groups and not taking it for granted,

> *"… for empowered, whenever I feel included, or especially a part of a group. It'll make me realize how lucky I am to be a part of a group that's going to take you in and accept you for who you are, and not going to shut you out, especially after hearing all of these pretty awful experiences people have." (S3)*

S2 talked specifically about feeling heard in the co-design sessions by the older students, even though she initially thought they would be mean,

> *"I have to take away um, just being more out there because they [more senior students in the sessions] were willing to listen to what I had to say, and they weren't mean about anything. I was scared of something that wasn't going to happen because everyone's older than me I was just scared of. I don't even know what I was scared of." (S2)*

S4 expanded on feelings of belonging, the empowerment it brings, and how one can use that power of belonging in a positive way,

> *"When you feel like you belong, it's more easy to advocate for yourself because you feel like you have a leg to stand on, in talking about what you're doing there…You're not so focused on feeling like you're trying to make other people believe that you belong… the*

risk of taking actions is lower, at least the perceived risk of certain actions is lower, so it's easier to take those actions. I feel like I belong, and therefore me taking action to include other people can happen. Um, It's the same thing, I think, with feeling like I belong. And therefore I have the power to include others." (S4)

S4 continued and shared the possible negative use of power when you feel like you belong,

"But it can also be the other way of, like, you feel like you belong. And so you have the power to exclude others from feeling like [they belong]; it goes both ways. But I'm not sure what inherently about feeling like you belong gives you power in a situation beyond just like the risk assessment changes. (S4)

Finally, three of the four student participants pointed to their realization of having the power to make people feel included,

"I can also approach that, as here's this other female in engineering, who, I have the power to make them feel included. Especially as another female in engineering, even if it's just feeling included in women in mechanical engineering, that's great too. Then it's something as simple as what answer did you get?...simple, everyday actions that can have positive ripple effects." (S4)

"Even people who aren't [included], if I can include them, then I should include them. Because I know [what] it's like to be stuck on the sidelines and not be included." (S2)

"We can design activities and assignments in a way that encourages collaboration and less power dynamics." (S1)

Seeing and Appreciating Power

Finally, another theme that arose was the change in perspective that the participants experienced. Some participants valued having "power" as a framework to understand the world around them, not just engineering spaces. S3 in particular emphasized being able to point to [social] identities as factors for discrimination that could be attributed to more seemingly harmless reasons. S1 begins with sharing how he was able to be more aware of power outside the co-design sessions.

"But I think the most surprising thing to me was that once I started keeping it [power] in the back of my head and started thinking about the power dynamics, especially in every interaction I've had like within the week, or even like in the sessions themselves. Are we all contributing to those power dynamics,...I think that we all contribute to these power

dynamics, and that we're not just disenfranchised by them, we are actively participating in them." (S1)

S4 also shared how power dynamics was a versatile lens,

"Power dynamics, I think, probably got broader and just in the versatility of it as sort of a label…There's obviously overlap like a power dynamic could be abused because this person is discriminating against this person because of x y, or z." (S4)

S4 continued to develop her understanding of power dynamics as she talked through her new connections,

"…but a peer wouldn't really have a power dynamic over another peer that they're discriminating [against]. But I guess maybe if you got the majority-minority thing, and in really any category we'll have some power dynamics and that sort of how that kind of discrimination arises, so maybe they are more intertwined than I thought." (S4)

S3 talked about the identity wheel framework and how it helped him understand power,

"The identity wheel really help me understand about the different experiences, different perspectives that people can have like, for example, for, like gender or race, or like language barriers or um socioeconomic status… it made me want to really think about how these different identities affect opinions, or affects the way they [people] are treated in the classroom, or like power dynamics, or the way they're [people] excluded like that. I guess a lot of times when we wonder like, how are these identities related to the way that people are excluded, and I felt like the identity wheel is often a key reason or not." (S3)

S3 continued to describe his newfound awareness,

"It's something I didn't really consider. I don't know if I didn't really think of it before it wasn't like one of my prior priorities or something I noticed when I'm in the classroom, but I guess really looking forward, I'm probably going to, notice more things, maybe in terms of groups. Or when someone says something… after doing this [research study] I'm more aware of ways people have been excluded or people felt left out. I don't think I really picked up on a lot of the ways different people could be left out before. And I think, from doing this I'm definitely. I hope I'm more aware of." (S3)

And continues to grapple with making sense of what he learned in the co-design sessions about others' experiences of exclusion, particularly those with different identities than his or of those in his social circle,

"a lot of those [experiences of exclusion] were, I don't feel like hard to believe, ... they're definitely real. I just never really thought people would do anything like that before but...I never heard stories of that happening, and I guess it's probably because a lot of people who I talk with are mostly guys...it's a surprising because it's just talking to a different group of people you really see a lot of ...or you learn about a lot of different experiences that people have experienced." (S3)

As student's shared their experiences, they noted the connection between feelings of belonging and those of empowerment, and how that feeling of empowerment could really be used to help those who are not experiencing feelings of belonging by taking an active role to include others.

Limitations

One critical limitation to acknowledge here is the identities represented in the students that participated in this study. We had two male identifying and female identifying students, but no students representing the experiences of non-binary individuals. We did not have students representing Black and brown experiences, which is important to note because these identities are underrepresented in engineering. We also did not have any white male-identitfying individuals, who represent some of the most privileged intersectional identities. Although no data on socioeconomic status was collected, many of the participants also mentioned being grateful that their families could financially support their education. These limitations are important to acknowledge because, as noted, experiences of power are tied to identity. We know there are other experiences with power that are not being captured here, on both extremes.

Discussion

Connection to Domains of Power
One important reason for this work is to continue to make connections between Hill's Domain of Powers and engineering education. From looking at student understanding of power, we see students referring to the different domains of power, although not always explicitly. Students are clearly able to name power dynamics in interpersonal interactions, whether it's with peers, teaching assistants, or faculty members. Students also discuss how disciplinary powers within engineering, such as grades and job referrals that reward "successful student behavior," are at the forefront of reasons why they might not question authority in the classroom or why they do tolerate discrimination from faculty members who hold the power to provide access to jobs. The students' unanimous agreement on what it means to hold power in a project group— being smart, competent, or knowledgeable— speaks to the cultural powers in engineering. As a discipline, engineers believe in meritocracy and value objective knowledge and positivist ways of knowing.

Finally, students point to structural power, when they discuss reasons why faculty might be less willing to start conversations of power due to time constraints or amount of risk involved.

In an effort to provide practice-focused findings, we encourage faculty to think about how they are reproducing exclusive engineering norms through the different Domains of Power. How are policies systematically disadvantaging students? How might applying the same late policies on homework affect students disproportionately? How can we embed the practice of positionality and being aware of the privilege or marginalization of different identities into the development of healthy teams? And finally, how can we continue to question what is defined as intelligence for success in engineering? These questions are just starting points. The following sections expand on student-faculty interactions and student-student interactions.

Student-Faculty Interaction
Responses from student participants suggest that instructors often hold an innate and frequently unexamined power over students that is present in even the smallest interactions. Some of this may be unconscious and ingrained through an educational system built on respect for a structural hierarchy, but it also comes from the real and conscious threat of consequences that can be wielded by faculty. While it may be obvious in the context of a classroom relationship, where an instructor wields disciplinary power over things like grades and extensions, this power dynamic creeps into all faculty-student interactions, due to an awareness that faculty provide access to industry connections and letters of recommendation. Engineering careers are also associated with high earning potential and the ability to provide financial stability. Notably, students of low socioeconomic status show greater financial motivation in attaining engineering degrees than their peers of high socioeconomic status [11].

All of this means that faculty have power not only over students' grades and academic lives in the classroom, but also the trajectory of their future careers and their access to social and economic capital. Awareness of this power differential cannot be divorced from student-faculty interactions, and faculty must acknowledge the discomfort of holding this power in order to be aware of it and act with intention. Faculty should be conscious of the weight that their words hold, even in casual interactions. They should also look for opportunities to cede power to students when appropriate, and to wield their power for positive change. As identified by student participants, changes to problematic power dynamics and engineering culture must start with those who already hold power, and faculty have the opportunity to lead the way.

Student-Student Interactions
The ways in which students perceive and interact with themselves and one another can lead to inequitable power dynamics within engineering student group environments. With engineering often being considered a field based on merit, the data suggests there is a culture of how students' perceived competency creates lateral and hierarchical power relationships such as

students who are viewed as more competent taking the lead and having more control, or students dividing work to play by their strengths or knowledge to achieve the best overall results. However, these power relationships support an ongoing exclusion of students from taking part in opportunities to collaborate and learn both collectively and equitably. Within engineering group projects, the awareness of one's own power granted by their experience can impact how work is distributed among the group. This finding echoes the work of Dringenberg et al. [12].

In addition, to expand on the previous section discussing how engineering students associate power in these spaces with faculty and believe that faculty can start conversations about this topic, there is an opportunity for faculty members to challenge the idea that success in engineering is based on a meritocracy. Faculty can encourage different thinking through discourse in the classroom and course rubrics. Faculty taking these steps can be a start to fostering a culture in which students hold intelligence with less value in social comparisons among their peers. Knowledge about a subject matter does not always make you better at designing a solution; being willing to learn, having curiosity, and expressing different ways of thinking and doing can also lead to innovative ideas.

Consciousness Raising
In the design of this study, there has always been a social justice framework of not only doing research to enact change but also creating change through the research process itself. We see students appreciating these new ways of thinking about their interactions with others. Not only are some students able to appreciate the value of diverse perspectives, they also point to their exploring of their privileged and marginalized identities as helpful to them in understanding how discrimination can happen based on identity, even when identity is not pointed to explicitly. Students also mention that talking about power has helped them see power at play, not only in engineering spaces but different social interactions in general. This finding points to power and identity potentially being considered threshold concepts that could facilitate conversations about discrimination and inclusion in engineering education spaces.

Conclusion
In this study, the research team looked at a subset of data from a series of co-design workshops with a cohort of four students and three instructors (two faculty, one instructor of record). This paper presents the results from student interviews, pre and post the co-design experience, and written reflections following each of the three workshops. Results point to student understanding of power in their engineering context. One main power dynamic that is continuously discussed is the power faculty have, not only in terms of the power dictating what happens in the classroom, but also the power to give access to students to opportunities beyond the classroom such as research opportunities, internships, and jobs. Students also discuss the salient nature of knowledge or intelligence as direct factors of holding power in a group project with their peers. This points to the historically problematic perception of intelligence through biased perspectives

that discriminate against racial and gender minorities. Overall, the co-design experience empowers students to think more critically about their role in interpersonal interactions. Students realize they have the power to include others and ensure more voices are heard.

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