The Power of Place: A Critical Examination of Engineering Enculturation & Identity Formation

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Abstract: Engineering identity formation is not simply the result of technical knowledge acquisition, but also that of enculturation. Both processes are intricately linked to the *places* (i.e., physical infrastructures) in which they unfold such as laboratories, classrooms, communal areas, and other engineering spaces on a university campus. Places act as a conduit for engineering enculturation, as it is within these settings that students are inundated with value-laden symbols & representations, participate in engineering activities and rituals, and are expected to adopt and embody dominant engineering mindsets and attitudes towards technical problem solving. Recognizing that the physical infrastructure of a place can serve as a tangible manifestation of broader challenges to addressing systemic societal issues, this paper delves into the institutional challenges of engineering enculturation by examining how physical spaces are implicated in processes that perpetuate dominant engineering ideologies and mindsets that sustain inequalities and social injustices (e.g., systemic racism, sexism, classism, and other forms of discrimination), within an engineering school and how certain places are perceived differently by underrepresented groups such as minorities, women, and LGBTQ+ students.

Employing qualitative research methodologies, we conducted 16, identity-based focus group sessions with undergraduate engineering students, each lasting two hours. Focus groups were organized to ensure consistency/similarity in terms of race, sexual orientation, and gender among participants. Our results highlight the pervasive influence of detrimental engineering ideologies [1], [2] within the everyday symbols, rituals, and curricula and other built infrastructure within an engineering school. Students from diverse social identities reported that these physical manifestations invoke tensions between their sense of belonging and the perception of depoliticization within the field of engineering [3], the centrality of military and corporate interests [4], [5], detachment from societal issues [3], and a glaring dearth of diverse representations within labs, classrooms, hallways, statues, public gathering areas, and study lounges.

These findings underscore the significance of considering the role of physical places in the conceptualization of engineering identity formation and highlight the necessity for institutions to address and overcome existing infrastructural challenges to fostering inclusive environments that cater to a diverse array of identities.

Introduction:

This study focused on the intersection of engineering places, engineering identity, and sense of belonging for engineering students. Place is an important element of identity formation [6], [7] and this is no less true for engineering identity [8]. We are just beginning to understand the role

of place for engineering identity, but for the most part, like the taken-for-granted culture, mindsets, and ideologies of engineering [3], [5], without deconstructing them, their negative influences on engineering students, and historically underrepresented groups in engineering in particular, remain hidden. This study seeks to link earlier work on socially deleterious entrenched engineering mindsets and ideologies to the study of place.

Engineering places are important to explore for several reasons. First, engineering students bring a variety of experiences from other places with them to college. This means that these past experiences become juxtaposed with the new places (and associated spaces) they encounter within a college campus and engineering schools. Students from diverse backgrounds will intersect with these places in a multitude of ways, including their K-12 educational experiences, their social identities, and their personal goals and aspirations. Therefore, it is important to understand the variety of ways students interact with places and how it manifests in their identity formation as engineers, as this will not be a straightforward process.

Second, unlike mindsets and ideologies (or culture in general), places can be more readily reimagined and altered. Moreover, while places and spaces have ideologies and mindsets embedded in them, physical structures are easily identifiable and delineated, and can actually be removed, as has been the case with the Confederate statue removal movement that has ensued since the COVID-19 pandemic [6]. Classrooms can be redesigned. New gathering spaces can be built, and current ones renovated. Symbols, signs, images, and other cultural expressions of engineering can be revisited for their obvious or subtle messaging. In contrast, mindsets and ideologies found in our texts, the way we talk, and how we behave are slippery and difficult to change on a short time scale. Also, unlike mindsets and ideologies, places are more local. They don't travel like ideologies and mindsets and are perhaps easier to analyze for messaging that hinders a sense of belonging for underrepresented students. Thus, place can be a level of intervention that is immediate and can eventually spark more comprehensive change in more obdurate representations of mindsets and ideologies. We thus do not argue that altering engineering spaces is the only strategy to pursue, but that we should add and perhaps prioritize this type of intervention to the tools we have for improving inclusivity and sense of belonging in engineering. Drawing from a series of focus groups held within the A. James Clark School of Engineering at the University of Maryland College Park, this paper aims to identify how *place (and the spaces associated with them)* intersects with student's engineering identity in positive and negative ways with the goal of better understanding how we can alter a place to be safer and more inclusive.

Place as a Mediator of Engineering Ideologies and Mindsets

We argue that place is an important dimension of identity formation and sense of belonging for engineering students. Most engineering undergraduates come to college with aspirations of

designing and building technologies. However, they do this within the context of unique places and among distinct milieu that reflects its own engineering culture [8]. Thus, engineering culture and the development of engineering identity is inextricably tied to the places that reproduce it and contains within it specific organizational patterns, embedded norms and routines, shared beliefs, and values that often mediate how students engage with faculty, staff, and one another. In short, culture cannot be decoupled from the place in which it is experienced and imparted. Extant research delineates visible manifestations of culture as "ways of doing things" within the classroom and laboratory spaces—which often prioritizes the teaching and development of technical skills immediately transferrable to the workplace [9], [10], [11], [12].

Current engineering education research on identity and sense of belonging has identified several engineering mindsets such as technical narrowness, meritocracy, the perceived "value neutrality" of engineering practice, and the profession's pervasive identification with corporate-military values which can directly and indirectly perpetuate inequities for engineering undergraduates [1], [2]. The razor-sharp emphasis on technical education at the cost of developing human-centered engineers and the insistence that engineering is a value-neutral practice leads to what is known as the socio-technical divide. The danger of this divide is that it reinforces deeply embedded cultural practices that work to downplay, obfuscate, or dismiss entirely the influence of social and structural factors that reproduce educational disparities among historically marginalized groups in engineering and further drive them away from the field [4], [5], [13]. The broader societal implication of this problem is that it limits the diversity of perspectives that practice engineering, which perpetuates the development of the unjust and inequitable distribution of technological consequences. We see this, for example, in the pervasiveness of algorithmic bias, infrastructure projects that harm minority communities, and a lack of (or undone) technologies that could benefit women and people of color [14], [15]. The recognition that we need to design culturally appropriate technology will remain unrealized if engineering culture continues to discourage participation from underrepresented minorities (URM), women, and the LGBTQ+ community.

Space and *place* are not synonymous terms. 'Space' is understood as the physical and material structures within a particular environment [16] and in the context of this study refers to those spaces often occupied by members of the engineering school such as lecture halls, classrooms, labs, offices, as well as other communal engineering makerspaces such as terrapin works, workshops and student start-ups. In contrast, 'place' is conceptualized as a richer, more nuanced construct that encompasses the meanings, values, and human interactions that permeate these physical spaces. *Places* contain symbols, signs, representations, activities, values, embodied attitudes, and physical structures that provide meaning to those traveling through it [7], [17], [18]and can communicate unwelcoming cultural messages to certain groups. It is through these cultural representations and practices that place engenders a sense of belonging for some and not others [19]. Depending on how individual spaces are designed and configured (e.g., placards

from corporate/military sponsors, photos of past engineers and their accomplishments, uncomfortable or inadequate communal spaces, notable lack of symbols relevant to marginalized groups, etc.), these places within the engineering school can be sensed as safe and inclusive or, conversely, hostile and exclusive. Thus, the *place*, in part, legitimizes engineering identity. The implications of this are that some *places* may operate as spaces of concordance or dissonance, wherein the processes of an engineering identity formation might conform to, conflict with, or partially displace existing values, norms and beliefs held by historically marginalized groups [20], [21], [22].

Within engineering education research literature, *place* is an understudied topic as a contributor to the reproduction of inequities, and therefore, as an inflection point for cultural interventions. Research that addresses the retention problem of underrepresented groups in engineering shows that students who remain unrecognized by their engineering professors and peers, who feel unwelcomed, unmotivated, or lack a sense of belonging, are more likely to leave to pursue degrees in other disciplines [23]. Since most research on belonging in engineering tends to focus on specific demographic populations (e.g., females, URMs, etc.) or categories (e.g., faculty, transfer students, international students, first-generation, etc.) and often investigate constructs such as "grit" [24], motivation [25], and identity negotiation [26], [27], [28], [29], [30], *place* as a point of intervention remains underexplored.

Figure 1 illustrates how we are conceptualizing place and associated spaces and defines its parameters, its cultural manifestations, and how those are shaped and maintained by the interactions between macro and micro-level social structures and socio-political pedagogical contexts. We see place operating at a meso-level between macro-level social structures like engineering mindsets and ideologies and micro-level contexts such as pedagogical approaches and associated norms and behaviors that happen within engineering places and spaces. Both macro-level and micro-level influences impinge upon how *place* is shaped and spaces are designed. At the macro-level, these spaces, if left unchecked, reflect dominant engineering ideologies and mindsets that potentially drive underrepresented groups from engineering. Likewise, at the micro-level, status quo pedagogical practices (e.g., large, stadium style classrooms) are shaped and shape engineering spaces and places.

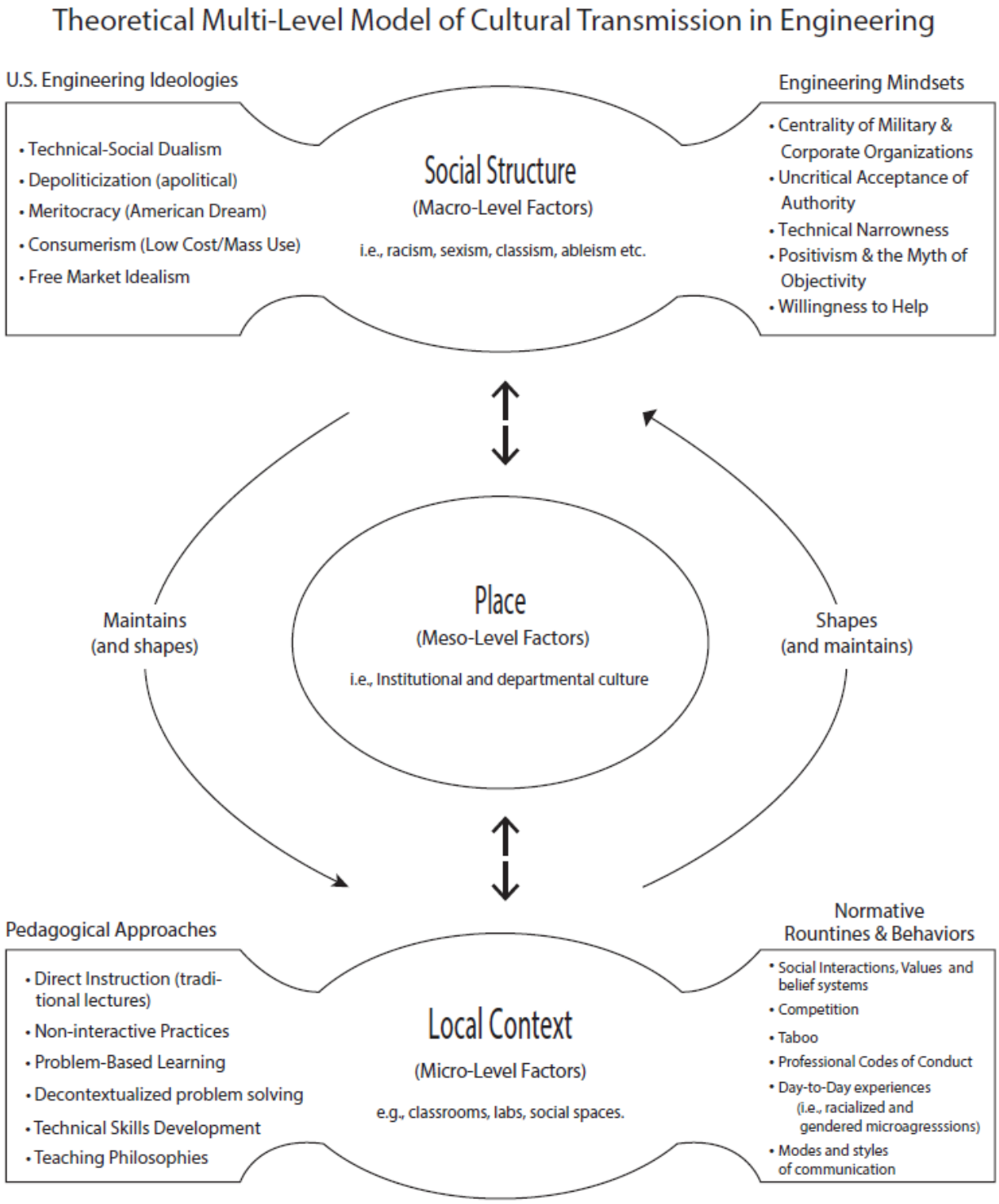

Figure 1: *Theoretical model of cultural transmission in engineering locating place and its associated spaces as a mediator of macro-level and micro-level factors.*

Engineering education scholars have long recognized that national-level (macro) ideologies and mindsets often shape and maintain behaviors and engineering modalities of thinking, classrooms

& laboratories (micro), thereby structuring curricular and pedagogical considerations [5], [31], [32]. Although more research in both domains is necessary to understand the role of engineering in advancing a more peaceful and prosperous society, it is insufficient by itself if *place* remains unexplored. Place is where the consequences of dominant engineering ideologies and mindsets physically manifest and send signals about who belongs. Thus, it is important to also identify and explore the ways in which faculty, staff, and students contribute to engineering culture, and how that culture is embedded within place. Therefore, the following research questions guide this study:

1. How do specific *places* within engineering schools impact students' sense of belonging?
2. What does *place* (e.g., the halls, classrooms, labs, offices, communal areas, etc.) have to do with the retention of underrepresented minorities (URM), women, and LGBTQ+ students in engineering?

Methods

Focus Groups: We conducted 16 identity-based focus groups (ethnicity, gender, sexual orientation, occupation, etc.) with students in late spring and early fall 2023. Potential participants for recruitment in this study were faculty, staff, or students who are affiliated with the A. James Clark School of Engineering at the University of Maryland College Park. Request for their participation in the study was through email and through posted flyers. We also recruited potential participants by reaching out to strategic partners across campus who are involved in Diversity, Equity, and Inclusion (DEI) efforts. Eligible undergraduate participants were required to be at least 18 years old and a current engineering student. We oversampled students from historically underrepresented and marginalized groups in engineering because the focus of this study is to understand how these students' sense of belonging is influenced by place.

During recruitment we asked potential participants to voluntarily provide certain aspects of their identity. These aspects included: class-level, major, race, gender, sexual orientation, documented disability, to name a few. When selecting participants for invitation in this study, we sought to maximize variability within these identity-based categories in an effort to capture a broad spectrum of experiences and viewpoints. For instance, in assembling the focus groups of Black Men, we not only looked at their shared racial and gender identity, but also sought to represent a diversity of academic majors within engineering, such as Aerospace, Mechanical, Electrical and Computer, and Fire Protection. We were equally diligent in grouping participants based on class standing, from freshmen to seniors, to reflect the evolving perspectives at different stages of an engineering student's academic journey. Furthermore, we extended our reach to include students who indicated that they came to the University of Maryland via non-traditional pathways, such as transfer students, delayed entry, and international students, thus enriching the dialogue with varied educational narratives. Additionally, we were conscious to involve students who self-

identified as having accessibility and disability (ADS) accommodations, acknowledging the unique challenges and experiences that they have as Clark School members. This methodical approach to participant selection was vital in creating a comprehensive understanding of the culture within the Clark School, reflective of its multifaceted student body. The final racial and gender demographic breakdown of student participants can be seen in figure 2. As for sexual orientation, 70% (51 students) of the students identified as heterosexual and 30% (22 students) identified as LGBTQ+.

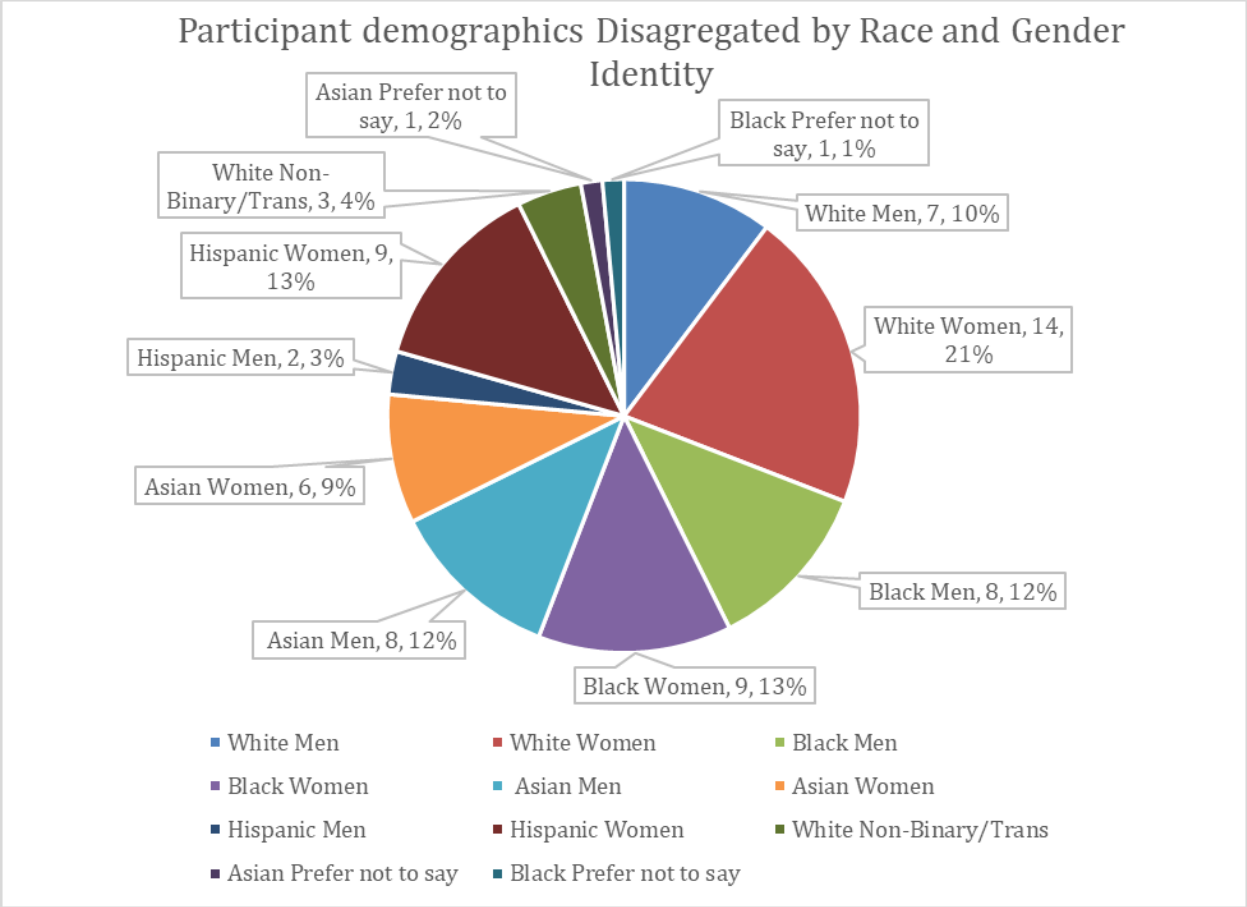

Figure 2: Racial and Gender Composition of Student Participants.

The focus group protocols had three distinct parts, each contributing to a comprehensive exploration of the experiences of students at the Clark School of Engineering—with a particular emphasis on *place*. Each focus group was facilitated by individuals who identify similarly to the participants and who had a demonstrated history of conducting qualitative research. Our facilitators were mostly current graduate students or had recently completed a graduate program. The rationale of having identity-based focus groups facilitated by professionals who share the same identity as the participants was to foster a sense of trust, comfort, and rapport within the group. This alignment can lead to more insightful and nuanced data, as participants may feel more empowered to share their perspectives and provide deeper insights into their identity-

related experiences. Table 1 below summarizes each of the three distinct parts of each focus group. For this paper, we primarily focus on the data generated by Part II.

Table 1: Summary of focus group protocols and key activities associated with each part.

Part	Description	Key Activities
Part I: Group Discussion	Participants shared personal and written stories about developing their engineering identity, focusing on places where they felt connected or disconnected to the Clark School and engineering. Images they brought facilitated group discussions to explore insights into engineering culture and identity formation.	Sharing personal stories, Bringing images of places, Group discussion
Part II: Image Analysis	Participants analyzed six images of various Clark School spaces, reflecting on their sense of belonging. They used dot voting to identify the most and least significant spaces and discussed how these spaces influence their engineering identity and feelings of belonging.	Image analysis, Dot voting, Group discussion on space impact
Part III: Q-Methodology (Statement Sorting)	Participants used Q-Methodology to sort statements about their engineering education, reflecting diverse views on dominant engineering cultures. They placed these statements on a Q-Board continuum to indicate their level of agreement or disagreement.	Statement sorting, reflecting on engineering education experiences, justifying statement position (written and verbal)

Data Analysis

Image Analysis: Undergraduate and graduate students were asked how they feel about images of six Clark School spaces that were purposefully selected to convey the physical instantiation of certain elements of engineering culture identified in current literature. Such images, which will be provided in subsequent sections, included classrooms/lecture halls, engineering labs, study lounges/workspaces, corporate/military representations, historical engineering figures, in addition to novelty/hallmark engineering maker spaces such as Terrapin Works and the Start-up Shell. For three of those spaces (Classrooms, Study Spaces, Labs), participants were additionally asked to indicate whether they Often, Sometimes, or Rarely feel like they belong in that space. Focus on these spaces was due to the expectation that while not all students may be familiar with

every space, they would at least have some interaction with classrooms, labs, and study areas. Thematic and open coding of focus group transcripts and written participant feedback forms revealed patterns and motifs within data [33], [34]). By systematically categorizing and interpreting these elements of student, staff, and faculty's lived realities within the theoretical framework of *'place'*, the analysis below provides a nuanced understanding of the cultural and social dynamics within the Clark School, highlighting areas of significance and potential for change.

Place and Sense of Belonging Among Engineering Students: A Macro-level Analysis

For the purposes of this paper, we categorized engineering spaces into three distinct yet interconnected realms: Formal Engineering Knowledge Acquisition, Engineering Symbols and Representations, and Engineering Student Expression. Each category offers a lens through which to view the complex interplay between space, identity, and belonging. Although this section will present an overview of each of the three categories of spaces and provide brief commentary on its implications for DEI, the following section takes a closer look at one category–Engineering Symbols and Representations.

Places of Formal Engineering Knowledge & Technical Skills Development Acquisition:

This category refers to those spaces of the engineering educational experiences commonly associated with the communication of content and/or the development of technical skills. Such spaces in this study include large lecture halls and engineering labs, as shown in figures 3 (right) and 4 (below), respectively.

Figure 3: Image of a Traditional Lecture Hall

Analysis of participant narratives revealed that in formal learning environments, there is a sentiment of being treated as numbers rather than individuals, highlighting a deficit in personalized learning experiences and attention. This issue is not just confined to classrooms but extends to the broader context of educational support and opportunities. Participants expressed concerns about uneven distribution of learning opportunities, access to faculty, and overall support systems that these are barriers to deeper understanding crucial for mastering complex engineering concepts. The sense of alienation and isolation experienced by some students in the lecture halls is a significant concern. As one student expressed, ""“I feel that when it comes to lecture halls, where there are 300 students, I feel more like a number, a statistic. In a lecture hall, we are a bunch of nameless faces.”

This quotation reflects the broader trend of the neoliberalization of higher education [31], [35], where lecture halls are communicating to students a 'banking model' mentality [36], [37], [38] towards teaching and learning. By emphasizing efficiency, the physical infrastructure also necessarily encourages standardization, and a one-size-fits-all pedagogical approach, often at the expense of personalized learning experiences and individual attention. This vision of education, partially structured by the built environment, not only exacerbates feelings of alienation and isolation among students but also poses substantial barriers to mastering complex concepts, particularly in fields like engineering.

The interplay between formal places of engineering knowledge acquisition is also of particular interest when it comes to understanding sense of belonging. Students in the Clark School often oscillate between competitive and collaborative dynamics that are partially a consequence of the physical structure and partially a reflection of dominant mindsets in engineering. Competitiveness is often rooted in a meritocratic mindset, where success is perceived as a direct result of individual effort and talent unaided by privilege and/or differential access to forms of social, cultural, or economic capital [39]. This belief is further entrenched by the notion that educational resources, opportunities, and letter grades are finite, thereby incentivizing students to try to outperform their peers. It is in large lecture halls and labs, where physical structures often lead to minimal student-teacher interaction and intensify the focus on individual performance. Thus, we see how the physical infrastructure can foster a culture of competition, often at the expense of cultivating authentic peer-to-peer as well as instructor-to-peer relationships.

Figure 4: Image of an Engineering Lab

Many participants feel that these tests do not capture their effort or growth and instead reduce the rich tapestry of learning experiences involved to merely transactional relations. The intense competition, coupled with gender dynamics and a lack of peer validation, contribute to a pervasive sense of isolation and a questioning of their own abilities and place within the engineering community. This dichotomy between external admiration and internal devaluation creates a challenging dynamic for some students, leading to feelings of inadequacy and a struggle to find their place within the engineering community. This underscores the challenges faced by those who lack prior hands-on engineering lab experience or feel marginalized within these settings. Such interactions not only diminish the confidence of these students but also limit the diversity of perspectives and ideas in group projects, ultimately affecting the overall learning experiences for all group members.

Places of Creative Engineering Expression:

This category refers to specific spaces in the A. James Clark School of Engineering meant to foster creative outlets for engineering practice. Makerspaces and student start-up spaces, commonly known as TerrapinWorks (Figure 5) and the Startup Shell (Figure 6) respectively, while designed to foster innovation and hands-on experiences, are perceived as not being uniformly accessible to all students. Furthermore, cultural and procedural deterrents present within the Startup Shell and Terrapin Works create significant barriers to inclusivity and accessibility, impacting the overall effectiveness of these spaces as hubs for innovation and collaboration. These perceptions result in disparities in who gets to benefit from these advanced facilities, potentially widening the gap between students with different backgrounds and levels of prior experience. Yet, the accessibility of these spaces is still recognized by students as possibilities for practical skills development and professional preparedness, making the equitable distribution of these opportunities a key concern.

Figure 5: Image of a public makerspace.

These places, while intended as spaces for entrepreneurial and creative endeavors, are perceived as exclusive and "off limits" to members of the student body who feel that they do not possess the prerequisite technical skillset to engage with this space. Additionally, the culture or "vibe" within these spaces sometimes aligns more closely with specific groups, potentially alienating others. This perception can deter a wider range of students from engaging with these opportunities, limiting the diversity of perspectives and ideas that are essential for innovation in engineering. As one participant who identified as a woman summarized, "These two places are advertised to incoming freshmen a lot. I don't know anyone who goes to either of these places. I think TerrapinWorks is for a very specific subset of people like the 3D printer fanatic guys. And I don't even know what the Startup Shell is for. It sounds like a place for business majors or Silicon Valley venture capitalist funding folks or tech bros who just want to get rich off their dumb ideas."


Figure 6: Image of student start-up space.

Lastly, there is a sense of confusion regarding the application processes, which are not clearly communicated or accessible to all students. This ambiguity can act as a barrier to entry, preventing interested students from fully engaging with the space. Moreover, issues with response time further contribute to a sense of frustration and exclusion. The perceived delay in feedback or guidance can discourage students, particularly those new to the entrepreneurial scene, from pursuing their ideas or seeking support in the Startup Shell.

Places of Engineering Symbols and Representations (Past & Present):

These are typically public, transient spaces within the Clark School where students encounter an environment saturated with visual symbols and representations emblematic of the dominant engineering culture. The design of such spaces are not merely decorative motifs but are imbued with the values, priorities, and ideologies of the field. Along the walls and hallways within the AJC, a significant portion of this visual landscape is dominated by the presence of the AJC corporate sponsors and military organizations, reflecting a complex interplay between engineering education and external influences. From participant reflections and interpretations of these spaces, we find that such symbols may inadvertently align students' perceptions of engineering with specific industrial and militaristic values—an idea that we further develop in the sections below.

Furthermore, in other curated spaces, students engage with key historical figures and can read narratives of UMD past engineering achievements. These visual representations serve as a tangible connection to the discipline's legacy, yet they also raise questions about inclusivity within the engineering community--potentially leaving students from diverse backgrounds struggling to see their own identities and, by extension, the contributions of those who share them, reflected in the field's historical tapestry. As we will discuss in the next section, the continued struggle for inclusivity is not only partially due to the lingering effects of historical injustices, but also a failure of considering how these engineering spaces reinforce subtle, but no less harmful, messaging surrounding who engineering is for and who and what it serves.

In table 2 below, we provide select supporting quotations from focus group participants that exemplify macro-level aspects of our theoretical model of engineering cultural transmission introduced in Figure 1. While the quotations were selected for their particular salience as it relates to the intersection of extant literature on engineering ideologies and mindsets and infrastructural design choices, we scrutinize and unpack the impact of these choices on sense of belonging in the following section.

Table 2: Select Supporting Quotations by Engineering Ideology/Mindsets

	Space	Select Quotations by Engineering Ideology/Mindset
Formal Engineering Knowledge Acquisition (Physical Infrastructure)	Lecture Halls	"Coming from a high school with limited STEM resources and opportunities, I've felt at a disadvantage compared to peers from more affluent or specialized backgrounds who arrived with advanced skills like MAT lab and CAD. I feel like I have to work twice as hard just to be on the same level." **(Meritocracy)**
	Labs	"It's like if you have had lab experiences before, you know what you're doing. And I really don't have that much compared to my classmates. Some of them have literally said to me, 'How do you not know how to do this?' Or they won't pick you to be in the group because they know that you're not as advanced. I just feel as a woman working in a group of all guys, I don't want to be the one that fails to use the power tools." **(Sexism)**
Engineering Creative Places Social Environment)	Makerspaces	"Now that I am a senior, I feel like I spend just as much time actually creating things and working with machines as I do in a classroom. So, I feel like education done right, is getting us to that point." **(Technical Narrowness)**
	Student Start-up Spaces (Entrepreneurial)	"I feel more connected towards the startup shells. Yeah. Like it develops our entrepreneurial skills which are required in the present world so that we can make things that help everybody." **(Free Market Idealism)** "I get why they advertise the Idea factory and start-up shell. But to me, at least at the grad school level, emphasizing innovation within the discipline itself and what engineering can do to make people's lives better. Not emphasizing what we can do to make money." **(Free Market Consumerism)**
Engineering Symbols and Representations (Symbolic)	Corporate Sponsors & Military Orgs.	"We don't have a dedicated engineering ethics class. So, it's not like we are really asked to think about the fact that some of us might help build warheads, or other technologies and like decimate communities by our engineering abilities. It just feels like they just don't really want us to think about it that much." **(Depoliticization)** "I feel most directly connected to the Clark school when I see this Northrup Grumman sign. This last summer I did an internship at there and have also been offered a job there after I complete my degree." **(Centrality of Military & Corporate Sponsors)**
	Historical Figures	"This is the face of Glenn L Martin. The more I went into the building I got used to being greeted by his face. I think it is a good way to introduce people to Lockheed Martin, the man the building is named after and the history of his impact on engineering." **(Technical Narrowness)**

In this section, we sketched out how macro-level ideologies and mindsets are reflected in place. In the next section, we explore the intersections between the micro-level and place by taking a deeper dive into one of the three salient ways participants were experiencing common educational environments - *Engineering Symbols and Representations*. This particular theme was selected not only for its direct relevance to student values, engineering mindsets, and ideologies but also because it exemplifies these relationships in a manner that is arguably more pronounced than the other identified themes. We argue the visibility of public spaces of symbolic significance to participants, accentuated by their daily experiences within them, amplifies their

impact on the collective consciousness of the student body. Furthermore, we show how these public symbols and representations can be interpreted differently by students holding marginalized engineering identities. Moreover, the potential for rapid transformation within these symbolic spaces presents a pragmatic advantage; modifications to these representations can be implemented more swiftly and with potentially less resource expenditure than the extensive overhaul required for physical infrastructures such as classrooms, communal student areas, and laboratories.

Places of Engineering Symbols and Representations: A Micro-level Analysis

The culture of the Clark School of Engineering is also reflected in symbols, murals, placards, art installations, names of buildings, and other design decisions. As students pass through these places, they are being asked the question, who does engineering serve? This section discusses students' impressions, feelings, and opinions on the cultural messages being communicated as they navigate the halls and communal spaces around the Clark School. From participant stories we see that the dominance of military and corporate interests induces anxieties in students who feel that they might be involved in future engineering work that directly results in the physical harm of people and communities. Such prevalent representations can challenge the sense of belonging, causing them to question their continuation in the major. Additionally, engineering representations that largely highlight the contributions of white men, as with the Innovation Hall of Fame, excludes the knowledges and contributions of people from non-European cultures to the field, also sending signals that certain groups don't belong.

Placards of Military Organizations and Corporate Sponsors: Ethical Tensions & Historical Reminders - The presence of placards of military and defense organizations and other corporate entities (Figure 7) within the Clark School of Engineering signifies a complex relationship between engineering education and the defense industry, interpreted diversely by the student body. The prevalence of these organizations, as reflected in the student quotes, suggests that the Clark School heavily leans on this network for career opportunities, influencing the perceptions of student's professional trajectories post-graduation, as the following participant quotation captures,

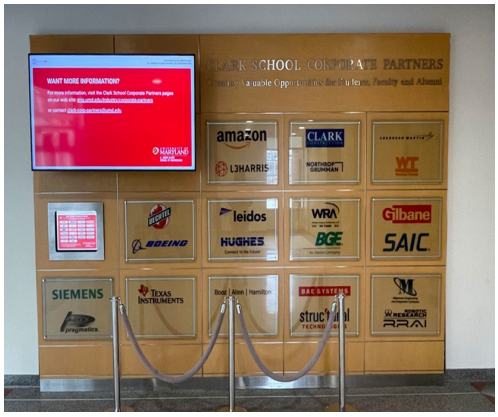

Figure 7: Image of Corporate Sponsors and Military Organizations Associated with the Engineering School

> "It's for all engineering majors, but it is especially for aerospace, and it's the constant dilemma and ethical tension about what to do with all this military-corporate attraction. And I would say that opportunities from the Clark School grow very heavily out of that network. As a future engineer, I don't want to be a

> part of all the bad things represented on that wall. And a lot of what this school does is pump out people to work for military defense corporations. So, I *do* [emphasis added by participant] think it is representative of the Clark School."

Conversely, there were some participants that did not feel ethically compromised about these spaces. As one participant stated, "I feel most directly connected to the Clark School when I see this Northrup Grumman sign. I did an internship there last summer and have also been offered a job there after I complete my degree." Although we did not find this to be a widespread perspective among minoritized identities in engineering, this participant's experience of securing an internship and a job offer illustrates the practical advantages of these corporate relationships, fostering a sense of direct affiliation and achievement with the school. Such experiences validate the Clark School's role not just as an educational institution, but as a launchpad for successful engineering careers within major industry players. Yet, the overwhelming negative association with these placards among participants who belong to historically marginalized groups in engineering must be considered alongside the few outliers that fondly interpret these symbols.

More importantly, the placards of corporate and military partners can lead to negative relationships that go beyond constraints on career choices. They can be deeply intertwined with profoundly personal and historical trauma for some students. As one participant shared,

> "So, I'm Cambodian. My parents are Cambodian refugees--they survived the Vietnam War and the Khmer Rouge, which was a communist genocide. But a lot of that history had to do with the United States going into Southeast Asia and interfering. So, there's always been that identity tension for me where I'm thinking I can't work for the military because the United States military caused harm to my parents in the past."

As exemplified in the quotation, the participant's identity, shaped by their family's suffering and displacement, clashes with the prominent representation of military organizations in the school, highlighting the complex and often painful intersections between personal histories and institutional affiliations. These symbols highlight the tight connection between the military and technological progress. However, for students with refugee backgrounds or those whose families have been affected by conflict, these symbols can challenge their ethical and personal values. As these students strive to reconcile their aspirations in engineering with their personal histories and ethical beliefs, the pervasive military undercurrent within the field can exacerbate feelings of alienation and internal discord, complicating their academic and professional journeys.

The relationship between the engineering profession and corporate/military interests also influences the engineering curriculum. As one student recounted,

> "I got into Fire Protection because I wanted to make buildings safer and protect firefighters. I thought that that is what my job would be when I finished my degree. And maybe there are some opportunities to do that, but I wasn't even aware of it actually until

> I got here. A lot of what fire protection engineering curriculum is about and the examples they give us is about protecting weapons from catching on fire or military equipment from exploding."

This participant's curricular experiences are contextualized or intentionally situated within the realm of military application. This revelation suggests a broader implication: that educational objectives and applications of engineering principles can be heavily influenced by military interests and the larger ecosystem of defense contractors that hire engineers. For the participant, this was an unexpected aspect of their chosen field, even obscuring non-military career options. This example indicates that the underlying motivations driving their education might not always align with their personal values when declaring a major. In other words, the participant's initial intention to contribute to public safety and firefighter protection was overshadowed by the realization that they might be involuntarily serving militaristic purposes. This mismatch between personal values and perceived educational focus highlights a potential disconnect for some students matriculating through an engineering course of study.

Historical Representations: Artifacts of Unequal Eras - Some of the representations of UMD's historical engineering figures contribute to feelings of inequity. Spaces dedicated to showcasing the achievements of past engineers, such as the Innovation Hall of Fame (Figure 8) and other engineering iconography, often highlight figures who may not embody the diversity and inclusivity values of the current student body. This can lead to feelings of disconnection among students who do not see themselves reflected in these historical figures or envision a grander future where they are a part of shaping a new narrative regarding who can participate in engineering. Moreover, the lack of representation of diverse figures in these spaces can perpetuate a sense of exclusion and undervalue the contributions of minority groups within the engineering field.

Figure 8: Image of the Innovation Hall of Fame.

Several focus group participants made observations that speak to the broader issue of historical underrepresentation and the need to actively acknowledge and affirm the presence of engineering students who identify as women or from minoritized backgrounds vis-à-vis artistic engineering installations stating, "Engineering is heavily White-male dominated, and there's not a lot of women in my classes, let alone Black women. So, when I walk through the Innovation Hall of Fame…it's just a hall of old White guys and I think it needs to be updated to show the contributions of people of color and women to engineering." The current state of this space, as

described, serves as a visual reinforcement of the dominance of white males in engineering, potentially perpetuating feelings of alienation and exclusion among students from minority backgrounds. The call for administrative support for inclusivity, a common theme in several focus groups, extends beyond just the physical space of the Hall of Fame. It reflects a broader call for systemic changes in the engineering field.

Other notable commentary that emerged during focus groups surrounded the complex legacy of Glenn L. Martin and the bust (Figure 9) that currently occupies the entrance to Martin Hall, an engineering building named after him [40]. As one participant fondly reflected,

> "This is the face of Glenn L Martin. The more I went into that building [Martin Hall] I got used to being greeted by his face. I think it is a good way to introduce people to Lockheed Martin, the man the building is named after and the history of his impact on engineering. And as for the Hall of Fame, I like it. It makes me feel nice that all these people came before me, and all this work that we are doing now is building on that. I guess I take a bit of pride in that."

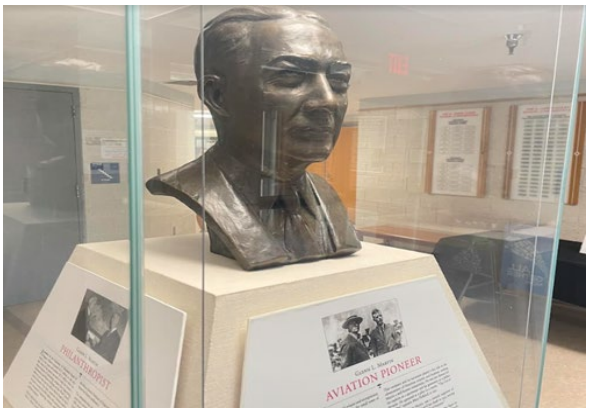

Figure 9: Image of the bust of Glenn L. Martin, Founder of Lockheed Martin

This comment is rather innocuous until it is juxtaposed with how some people of color react to its presence:

> "I chose this image as my space of disconnect because one of my classes was in Martin Hall. At first, I didn't know who that guy was, and my professor told us about how he was really racist. So, every time I walk in [the front entrance of Martin Hall] I see this thing… I don't know, it just makes me disgusted. Because he did his best to fight to keep Black people out of engineering. And so, I guess seeing that just brings bad thoughts, memories, so I don't like to walk by it."

In stark contrast with the first quotation wherein the participant associates the symbol with achievement, the second highlights how the commemoration of some historical engineering figures becomes entangled with the ugliness of racism in the US. This can and does deeply affect the sense of belonging and comfort of students, especially those from marginalized communities. The presence of Glenn Martin's image, instead of being a source of inspiration, becomes a reminder of a discriminatory past and signals to some students that this place might be a hostile learning environment.

Finally, the desire for recognition and validation extends beyond the broader categories of race and gender to encompass specific disciplines within the engineering field, especially those that are smaller or less recognized. As one student in Fire Protection mentioned:

> "I feel like these people could have resonated with me, but nobody in fire protection is included in the Hall of Fame. So, it really doesn't apply to me. And I know there have been people within fire protection who have made considerable changes to the field, and we recognize them in our department. But I feel like the forgotten child of engineering here at Maryland because of how small of a major we are."

The sentiment expressed here by a Fire Protection student conveys a sense of being overlooked within the broader academic community. Their perception of underrepresentation is not just a matter of visibility; it's interpreted as a signal of their field's perceived insignificance. This lack of acknowledgment for smaller, perhaps more niche majors can foster feelings of alienation among students dedicated to pursuing these disciplines. Therefore, the critical issue in the representation within all these spaces, The Innovation Hall of Fame, statues, corporate sponsors, is not only about who and what is being acknowledged but also about who and what is conspicuously absent. These reflections bring to the forefront the critical importance of representation and inclusivity in transient spaces. They highlight the need for a more diverse and accurate portrayal of contributors to the field of engineering. Such inclusivity not only honors the past but also inspires current and future students, fostering a sense of belonging and pride in their academic institution.

Discussion: Place & Implications for Sense of Belonging

From participant narratives, we see that places of engineering identity formation are perceived as more than functional spaces to develop and practice engineering understandings, habits, attitudes and skills, they also influence student perceptions of who belongs and who can contribute to the discipline. It is in large lecture halls and lab spaces that the mindset of meritocracy becomes entangled with the current agreement of scarcity [37], or the fallacious belief that resources, such as educational opportunities, grades, and instructor recognition are finite. This notion fosters a competitive environment, where students are pushed to outperform their peers, leading to behaviors such as perfectionism and workaholism.

We also see from participant narratives how existing infrastructure design reinforces competition by shaping instructor perceptions of pedagogical possibilities and methods of evaluation such as grading on a curve, encouraging students to view learning as an outcome rather than a process. In large lecture halls, the physical structure often conditions classroom culture–incentivizing limited student-teacher interaction. Professors in such spaces may opt for more traditional, direct instruction (i.e., sage on the stage) teaching methods given the perceived obstacles that large lecture halls provide. To the extent that such spaces encourage traditional pedagogical practices, it is not uncommon to find what critical theorist Paulo Freire (1968) describes in his seminal

work *Pedagogy of the Oppressed* as the banking model of education [38]. In such a mode, professors are seen as simply ultimate purveyors of knowledge who make knowledge deposits only to be withdrawn by students during high stakes assessments.

Moreover, the critique of engineering symbols and representations—particularly the emphasis on corporate and military affiliations—provokes a deeper reflection on the ethical implications of such affiliations. How do these symbols influence students' perceptions of their future roles as engineers, and what are the consequences for those whose identities or personal histories are at odds with these dominant narratives? This line of inquiry challenges us to consider the ways in which institutional affiliations can shape, and sometimes distort, the educational experience and sense of belonging. In re-humanizing engineering spaces, we should pose the question: engineering for whom or who does engineering serve? From participant stories we see that the dominance of military and corporate interests induces anxieties in students who feel that they might be involved in future engineering work that directly results in the physical harm of people and communities. Such prevalent representations can challenge the sense of belonging, making them question their continuation in the major. Additionally, engineering representations that largely highlight the contributions of white men, as with the Innovation Hall of Fame and , excludes the knowledges and contributions of people from non-European cultures to the field thereby sustaining the implicit and problematic agreement to privilege Eurocentric ways of knowing, thinking, acting, and being. Yet, these aspects of place are not immutable. What symbols and representations might we add in order to signal to those who pass through that this place is dedicated to the agreement to center humanity, nature, and the world as the entities in which the engineering profession serves?

The subtle, yet no less impactful, framing of engineering problems around military and corporate contexts within some textbooks, we feel, is a quintessential example of a mechanism that works to sustain dominant paradigms in engineering culture. Antonio Gramsci's (1965) concept of the hidden curriculum is relevant here. Education and educational content, far from being neutral, is saturated with the ideologies of dominant social groups, serving as a vehicle for perpetuating their hegemony [41]. The field of engineering education is no less susceptible to such mechanisms. By framing engineering challenges within the realms of military and corporate priorities, textbooks (in)advertently communicate to students that these sectors are not only central to the field's application but also desirable arenas for their future contributions. In this way, some textbooks may function to legitimize and normalize the primacy of militaristic and corporate-driven engineering training, thereby shaping students' professional aspirations and ethical perspectives in ways that reinforce existing power structures. This underscores the importance of critically assessing educational materials for their role in upholding or challenging hegemonic narratives within the engineering discipline and broader society–an avenue that we wish to explore further.

From an STS perspective, policy is considered an integral part of infrastructure, as it shapes the context of the specific places in which scientific and technological work unfolds. Policies dictate what is built, how it is used, who has access to it, and the norms of its use and conversely, the consequences of a lack of transparent policy around how spaces are regulated. Yet, policies also must be translated and performed, and those performances are in part guided by those who do the interpreting of policy [42]. From this study we have found that due to unclear policy and protocols, participants appropriate workspaces as study spaces, and makerspaces become places of recreation for certain clubs and affinity groups whose members are largely comprised of male students—thereby reproducing gendered perceptions of who this space belongs to. How might we open workshops and makerspaces, which have traditionally been viewed as incubators of engineering innovation, to be welcoming to diverse identities, non-STEM majors or the broader community? What policies and "ways of doing things around here?" might need to be reconsidered as we look to foster a culture of interdisciplinary innovation and discourage technical narrowness and compartmentalization? And how might these spaces enforce the spirit of those policies?

Conclusions & Recommendations

The rich narratives and participant descriptions of experiences within specific engineering places are compelling and invite us to consider how physical infrastructure can be seen, navigated, and interpreted in multiple ways. Students bring to these cultural cues not simply their lived experiences, but intergenerational understandings as well. This notion is particularly resonant for historically marginalized students, for whom educational environments can either signal belonging and potential or reinforce feelings of exclusion. In pursuit of achieving progress towards institutional DEI goals, we feel that educational environments can and should serve more than simply academic-related needs. By grounding this study as an exploration of *place*, participants are invited to co-construct and reconfigure current and future space arrangements that can challenge problematic aspects of dominant engineering culture. Intentionally designed and curated spaces that reflect the values and voices of diverse identities can inspire, encourage, and nurture students' mental growth.

By re-imagining *place* as a level of intervention, this study was able to provide administrators and those with decision making power in the Clark School actionable suggestions that could deepen its commitment to DEI. As it relates to our analysis, some of these recommendations included reimagining success and diversifying symbols of achievement that adorn engineering spaces, cultivating mentorship programs that reflect a spectrum of identities, and celebrating the contributions of underrepresented groups in engineering, and rewriting a mission statement in a way that students can "see" themselves and their values being reflected back to them. We offered detailed recommendations to adjust the visual signals students encounter, aiming for a more balanced representation of the various engineering fields available for exploration—since

participants indicated that they were uncomfortable with the preponderance of companies either associated with militarism or ethically ambiguous engineering work.

Participation in the project has also profoundly transformed our approach to curricular design and how we engage with engineering students. This involvement has heightened our awareness of the underlying values and assumptions embedded within the engineering curriculum and has prompted us to critically engage with content choices and to seek diverse methods through which that content is delivered. In short, this research has fed into a framework of critical pedagogies where the researcher is simultaneously an educator that reflexively uses what they learned to adjust curriculum [43]. This standpoint has led to new learning experiences where engineering students are asked to examine and critique the current arrangement of spaces on campus in addition to engaging in conversations with one another in engineering ethics courses that actively interrogate these dominant images—inviting a dialogue regarding how they might subvert or challenge dominant ways of doing things. By integrating these critical and reflexive practices into the curriculum, our aim is to empower students to become not just skilled engineers but also socially conscious individuals who are capable of contributing to a more inclusive and diverse engineering culture [44], [45], [46].

In conclusion, we invite the broader engineering community to reflect on and address how the tangible and intangible aspects of their own institutions—ranging from physical layouts to policies—affect the experiences of marginalized identities in engineering spaces. It's a call to embrace a more thoughtful, democratic, and inclusive approach to shaping educational environments, one that fully acknowledges and nurtures the diverse identities that populate them.

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