Understanding the Pathways of Students with Normative Attitudes in Engineering

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***Abstract*—Engineering culture has traditionally limited rather than fostered diversity in engineering. This culture serves to limit representation of diverse individuals within engineering and create environments that are detrimental to creativity, problem solving, and productivity. One way to address this issue is to understand how students align themselves with the cultural values of engineering and navigate their pathways through earning their engineering degrees. We present an analysis of ten participants previously identified through attitudinal survey data as belonging to a "normative" attitudinal group of engineering majors. These individuals provide a way to understand students who are attitudinally similar to the accepted norms and practices of what it means to be an engineer. Results indicate the importance of social resource experiences in engineering and on the widely held belief that success in engineering is born out of hard work, consistent with other studies. These findings outline ways in which engineering culture can shape student attitudes and actions towards learning engineering. Understanding this group may provide ways to change engineering culture to be more inclusive for all students. Our research begins to describe particular cultural practices and values to improve the recruitment, training, and retention of a broader population of engineering students.**

***Keywords*—engineering culture; motivation; student experience**

I. Introduction

Extensive efforts and research have been conducted to increase the number and improve the experiences of diverse individuals in engineering [1], [2]. While results have generated some change, the proportion of diverse engineers [3] and the quality of their experiences continues to limit underrepresented student enrollment in engineering and matriculation to the engineering workforce [4]. Specifically, the persistent features of engineering culture have been shown to limit the recruitment and integration of diverse individuals. The culture of engineering serves to limit the ways diverse students can integrate their interests and background experiences with what it means to be an engineer [5], [6]. When individuals are unable to see congruence between the role of being an engineer and who they are as individuals, they are more likely to display reduced motivation and belonging [7], both of which have been tied to decreased performance and retention in engineering environments [8], [9]. Additionally, when students fail to feel that they belong in engineering, it is often perceived as the student's fault rather than the practices of a community [10].

Further, a growing body of literature has shown how accepted engineering values can shape engineering student experiences. Godfrey and Parker have noted that the culture of engineering education values technical prowess and concurrently views diversity as irrelevant [6]. This perceived irrelevance of diversity in engineering environments serves to further isolate students. Building on this work, Cech and Waidzunas [5] showed in their research with lesbian, gay, and bisexual students that the cultural elements of engineering negatively influence diverse students' experiences. Cech and Waidzunas explored the experiences of students with non-visible diversity but did not explore how other underlying characteristics, like students' attitudes, influenced student experience and belonging in engineering.

William Wulf's model of "individual diversity" and studies in attitudinal diversity [11], [12] seek to understand how latent or underlying attitudinal differences of individuals foster other aspects of diversity. Our previous work quantitatively

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defined groups or attitudinal profiles of students who possess different beliefs, motivations, and identities in engineering at the beginning of their engineering degree [12]. The purpose of this study is to leverage these existing profiles to understand the ways in which engineering undergraduate students with various attitudinal profiles develop their engineering identities, navigate engineering culture, and contribute to reifying the hegemonic culture of engineering. To begin to understand how students' attitudes affect their pathways in engineering, this paper concentrates specifically on one empirically identified group of individuals from this larger study—"normative" individuals who belong to the most densely populated attitudinal profile—to answer the research question: "How do normative students develop their engineering identities and navigate engineering culture?" This research question is explored through the use of qualitative data that richly highlight the ways in which students navigate their pathways into engineering.

II. Background

Students' development as engineers requires legitimate participation and recognition within that social sphere [13]. However, these requirements are often reserved for students who are aligned with the culture of engineering. This practice may be exclusionary to students who hold non-normative identities, mindsets, or attitudes within engineering. Students who do not see themselves as coders, nerds, or designers, but as other identities that "break" the engineering stereotype may be discouraged from forming alternative ways of becoming engineers [14]. Ultimately, engineering culture puts the burden of aligning and defining what it means to be an engineer on the student.

Previous work that focused on students' development has not taken into account the individual attitudinal differences in how students see themselves as engineers (i.e., identity). This research is motivated by a number of factors, including attrition rates, exclusion of underrepresented groups, and a sense of alienation by students in their education [15], [16]. Identity-linked alienation has been documented for students, especially diverse students, in engineering programs. Marra, Rodgers, Shen, and Bogue [17] surveyed 113 students leaving engineering and found that lack of belonging in engineering culture was the only significant predictor of students switching into a non-technical major. In addition, the case study of Inez, a student who wished she "belonged more in this whole engineering thing," illustrates the disenfranchising experiences of a particular student from a non-normative background in regards to socioeconomic status, gender, race, ethnicity, and other social categories [18]. Other work also illustrates that students who think differently may also feel alienated in engineering [19]–[23]. To unpack and change the current culture of engineering, it is important to understand the ways in which students in normative and non-normative groups experience and persist in engineering.

III. Methods

An exploratory phenomenological approach was used for this study to understand our participants' "lived experiences" as engineering students [24]. This approach aligns with our research question involving the experiences, perceptions, and attitudes of students in engineering. An exploratory approach was chosen since we are interested not only in what attitudes and experiences our participants chose to discuss but also how these topics influenced their engineering development and feelings of belonging. Data were collected and analyzed to answer the following research question: How do normative students develop their engineering identities and navigate engineering culture?

A. Participants

"Normative" and "non-normative" attitudinal profiles were empirically characterized for 2,916 undergraduate engineering students from four U.S. institutions in the first phase of the project [12]. These attitudinal profiles were independent from demographic indicators and other *a priori* assumptions of student groups and were developed from multiple affective factors including Big Five personality traits, identity, grit, motivation, and belongingness. The normative group was defined by high feelings of belonging in engineering, perceived future usefulness of engineering tasks, and clear future goals. Additionally, this group was less likely to be extroverted, neurotic, and avoid doing work [12]. A total of ten participants were interviewed from the normative group. These students self-selected to participate in the interviews in response to targeted e-mails to the normative group seeking participation.

B. Setting

The four large U.S. research institutions serving as sites for this study are geographically diverse. Two institutions are located in the South, one in the Midwest, and one in the West. One Southern institution is a predominately white institution (PWI), while the other is a Hispanic serving institution (HSI). At least one normative participant was interviewed from each institution. Table 1 shows participants' pseudonyms and various demographics.

TABLE I
Normative Participants' Institutions and Self-Identified Demographics

Participant	**Institution**	**Gender Identity**	**Ethnicity (write-in responses are quoted)**
Alicia	South PWI	Female	White
Dominic	South PWI	Male	White, "German"
Pilar	South HSI	Female	Hispanic, "Colombian"
Aaron	Midwest PWI	Male	Hispanic, "Hondurian"
Kathie	Midwest PWI	Female	White
Keyla	Midwest PWI	Female	White
Sean	Midwest PWI	Male	White
Bradley	West PWI	Male	Hispanic, "Mexican/ Salvadorian American"
Elizabeth	West PWI	Female	White
William	West PWI	Male	White, "Scottish"

C. Data Collection

Data were collected through interviews. A semi-structured interview protocol guided questions but allowed for opportunities to explore responses further, especially those that were important to a students' experience or needed further clarification. Participants were asked to discuss their stories of choosing engineering, their experiences in engineering, and more targeted questions directed towards attitudes of the normative group date [25]. We also asked about how they defined engineers, how their identities fit with their descriptions, their feelings of belongingness, and their ability to connect what they were doing in their engineering courses with their future goals [26]. Questions regarding future goals were targeted as the "normative" group was characterized, in part, by higher perceived connections to the future. Examples of questions asked during the interviews are as follows: "How did you get into engineering?" "Who can do engineering?" and "Do you feel like you belong in engineering?" Interviews typically spanned 45 to 60 minutes each and were audio recorded in a private room located at the participant's university. All interviews were professionally transcribed verbatim. The entire research team assisted in data collection and had completed human subjects research training. Institutional Review Board approval was obtained for all data collection and recruitment procedures. This paper reports the initial themes that have emerged from analysis of the normative group's first interviews.

D. Data Analysis

Data were analyzed using R Statistical Software [27] and RQDA, an R package for qualitative data analysis [28]. We chose this software because it is open source and highly flexible, permitting reproducibility of this method by the external community. Our analysis team first analyzed the same participant to gauge reaction to student interview responses and develop consistency in coding. Subsequently, each researcher analyzed a different interview per round of analysis. The analysis team met each week to discuss findings before beginning a new round. If patterns developed during these meetings, and agreement was clear, a beginning theme emerged; however, if disagreements arose, data were compared side by side and brought to the bigger group for discussion. This consensus coding procedure ensured that the large research team was in agreement with the emerging results from the data.

Interviews were analyzed using thematic analysis [29]. First, audio for each interview was used to obtain familiarity with the participant's voice and to correct errors in transcripts. Additional reading and rereading of transcripts was essential to develop familiarity with the data and participant perspectives. The first pass of codes was created to describe the participants' words, experiences, and values. These codes were sorted into larger categories, formed by generating unanimous decision from the analysis team throughout the process. Categories emerged around participants' attitudes and interpretations and through analysis and discussion were revised to the final themes.

IV. Findings

Although these students were classified as normative through previous quantitative characterization, there remained a great variety of experiences and attitudes between participants, particularly in their views of the future. We present two emergent themes that were reflected by all our normative interview participants and inform how students with normative attitudes navigate their pathways in engineering: (1) early engineering experiences with social resources and (2) the need for hard work and determination in engineering.

A. Early Engineering Experiences with Social Resources

Nine of ten participants identified persons who informed them about or encouraged them to consider engineering as a career. These mentors were often male family members or STEM teachers in high school . Participants claimed that their social resources not only provided opportunities for them to engage in engineering activities but also encouraged them to pursue engineering in college.

Aaron, a computer engineering major, was told by an algebra teacher that going into psychology would be a "waste" of his potential for science and math.

> I'd say my big interest in engineering started, ironically, after a parent/teacher conference in high school. I was going into psychology at that time, but then my teacher just flat out said it would be a waste of the potential I had in mathematics and science to go into that field and told me I should look into engineering.—Aaron

This teacher also encouraged Aaron to take a programming class and recruited him to join a computer club. Aaron attributed his interest in pursuing computer engineering to his enjoyment of that class.

Bradley, a computer science and engineering student, highlighted he grew up heavily around technology. He attributed this exposure to his cousin and uncle who spent time coding and building computers as their hobbies.

> For most of my life, I've just been growing up with technology and a part of that was my uncle and my cousin were really involved. My cousin, he would be coding websites and my uncle would just be working on building computers and taking them apart and looking at them. Whenever I would be around them, I would just do stuff with them. That just sparked it (interest in engineering).—Bradley

Bradley views this "tinkering" with family members as the root of seeing himself as an engineer and ultimately choosing engineering in college.

Kathie is an aerospace engineering student. She reported that her parents, although now working in business-related professions, both "pushed" her to do engineering. Her father, in particular, would engage Kathie in conversations related to engineering, which furthered her interest in pursuing the degree.

> My dad [is] an engineer, a science guy at heart, so I feel like he definitely ... My two younger brothers aren't really as engineering-focused so I think that he definitely would turn to me to talk about stuff like that. I feel like those kinds of conversations kind of influenced me to definitely pursue it (engineering). —Kathie

Kathie also identified five different male family members—her father, her grandfather, and three uncles—who were all engineers or who had done engineering in college. Of all the participants, Kathie expressed both the strongest social resources and the most unwavering connection to engineering. Kathie stated that she had "always known" that she wanted to be involved in aerospace engineering, dating back to when she was three years old. Her supported experiences as a child, such as attending space camp, strengthened her interest in engineering.

There was one participant in the normative group who did not identify an individual who encouraged her to pursue engineering; Pilar is a non-traditional student studying biomedical engineering. Although she had no direct familial connection to engineering, Pilar identified that "science and math were always in [her] family." Pilar's father ran a veterinarian clinic in her home country, which inspired her to go to a veterinary program. However, Pilar's positive experiences with her father's veterinary practice were overshadowed by her aversion to the "business emphasis," leading Pilar to drop out of school.

> What I came to realize as I got older was that it was not so much in this country that it was on such a business emphasis and forgetting about the patients, but that that's the way it is everywhere, just my dad didn't carry out his clinic that way.—Pilar

After several years of working towards an associate's degree in neuropsychology, Pilar decided to study full time in biomedical engineering. She was motivated by the new major being a "happy medium" between veterinary practices like her father and a potentially successful career. Although Pilar did not explicitly identify particular family members who encouraged her to pursue engineering, she did identify sources of social influence that led her to her ultimate education in engineering.

B. The Need for Hard Work and Determination

Every participant identified that being willing to work hard is essential for success in engineering. These students did not discuss a desire to work hard for the sake of working, but saw effort as important to attaining their engineering goals. Students described the connection between hard work and engineering success as necessary. Without hard work, becoming an engineer is impossible. Students felt that an individual was committed to and belonged in engineering based on their willingness to put in the required time and effort. A select few of our participants expressed beliefs that one's determination could not be grown or enhanced—one simply had the "drive" or did not. All of our participants conveyed confidence in their determination to succeed in engineering.

Sean is a construction engineering and management major. He exemplified the beliefs shared by all the participants. He viewed engineering as a difficult field and identified being "willing and able" to put in hard work as necessary components for success. Sean also believed that those two factors guaranteed success in engineering. He stated,

> I think I can [succeed in engineering]. It is difficult. It involves a lot of hard work, but as long as you are willing and able to put in the work, you will be successful.—Sean

Beyond identifying that hard work and determination were necessary for engineers, participants also reported that they possessed these traits. Participants saw themselves as capable of putting in work and, consequently, capable of doing well in engineering. Both Pilar and Keyla, a chemical engineering student, discussed how determination influenced how they saw themselves as engineers.

> I don't think I'll ever be one of the ones that get it, you know, but if I put in enough effort I'll pass the class, I can ... I'm trainable, let's put it that way. —Pilar

> I feel like anyone could do engineering. I feel like you need to be really determined, and want to do it. I feel like that's the driving force, if you want to do it. [....] I'd say I'm kind of determined. I want to do well, and I like to work.—Keyla

Dominic, a mechanical engineering major, presented a qualified view of hard work and determination as they relate to success in engineering. Although Dominic placed value in "try[ing] with everything you got," he recognized that some personal characteristics would make engineering easier for certain individuals. However, Dominic maintained that anybody who "really wanted to" could succeed in engineering if they try hard enough.

> I believe that if you truly want to do it, anybody can do it. Granted, sometimes it comes way easier for certain people than other times, but, if you put your best foot forward and try with everything you got, you could do it. Sometimes there might be better engineers than others just because of how your mind works or the gifts that you were born with. But if you really wanted to I think anybody could do it. —Dominic

Two participants, Kathie and Aaron, asserted that while drive and effort are essential for engineering, there were other important traits that are unteachable. Both participants believed that certain skills such as problem solving or leadership are innate talents that cannot be simply taught or learned.

> I definitely have the drive and I feel if you have the drive you can pretty much do anything with time and effort. If I don't have the technical skills when I go to somewhere, you can teach someone technical skills. That happens all the time. You can't really teach them people skills and you can't really teach

> them how to be an ethical person and you can't really teach someone how to be a good leader.—Kathie

Kathie and Aaron's beliefs about intrinsic traits were a point of tension within the views generally held by the rest of the normative group, but were not emphasized. The normative group as a whole prioritized hard work and effort and attributed their willingness to exercise these traits to an internal, unchangeable desire to do engineering.

C. Summary of Results

Exposure to engineering and encouragement from influential relationships prior to entering college both bolstered the interest and motivation of students as well as set expectations for engineering behaviors. Students believed that engineers require well-defined interest and motivation to succeed, while elucidating that this motivation must be coupled with significant conscious effort. While students associated their initial interests in engineering to their upbringings or prior experiences, most students conveyed their drive and determination as innate traits within themselves or did not specify the origin of these characteristics.

V. Discussion

Participants were categorized into the normative group irrespective of any *a priori* assumptions about their beliefs or their demographics. This group, although classified as normative based on methods of clustering, contained an incredibly diverse population of students in terms of race/ethnicity, gender identity, ability status, and sexuality. Attempting to characterize the normative group in terms of one or more of these demographic markers (e.g., "normative engineering students are mainly white men") would fail to represent the breadth and diversity of this group which has been selected for their similar attitudes, beliefs, and values. Regardless of their "traditional" markers of diversity, this normative group possessed key similarities related to their early experiences and expectations with respect to engineering.

Up to this point, we have focused on the attributes of our participants and their descriptions of their experiences in and interactions with engineering. However, it is also important to interpret and explain how our findings relate to established theories and to situate these themes within the current literature. Based on the emergent trends within the data, we focus our discussion in two areas: social capital and grit.

A. Social Capital

Social Capital Theory is one of the most widely used concepts in social science [30]. Bourdieu [31] defined social capital as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition" (p. 248). Work studying social capital in engineering has shown that first-generation students [32], women [33], and other underrepresented groups [34] may have limited access to particular forms of social capital which are most valuable in engineering. While previous work indicates trends between social capital resources and demographics, this study did not recognize visible markers of diversity (e.g., sex and ethnicity) of students as necessarily connected to access to social capital in engineering, prior to attending college.

The cohort of participants in our study, with one exception, Pilar, exhibited strong and explicitly acknowledged prior engineering experiences through familial or instructor influence. Specifically, these resources facilitated the development of students' interest in engineering. This result expands previous work in social capital that has been shown to predict a number of important educational outcomes, including college attendance [35] and occupational outcomes [36], to explicitly highlight the role of social capital resources in engineering interest development. Developed engineering interest can allow for increased recognition and legitimate participation in engineering. Additionally, students with particular family relationships, role models, and networks have an easier time navigating the structures and demands of higher education, especially in engineering [34]. Often, prior work in this area has focused on social capital of first-generation students or international students that may struggle with the structures and systems in higher education. Our work shows that students who enter engineering with particular attitudes and beliefs that align with the cultural norms of engineering may be better prepared to navigate higher education and have higher social capital than their peers. Our participants' prior experiences and networks, some of which included engineering activities and classes not necessarily offered in all educational settings, facilitated an engineering interest prior to college that resulted in choosing engineering as a major. This developed interest has the potential to provide these normative students with an advantage over students without a developed engineering interest, as interest has been shown to foster student pursuit of engineering knowledge and aligns with students' descriptions of "just having it [interest, drive, etc.]" to do engineering work [37].

As a counter case, Pilar did not identify a particular person who encouraged her to pursue engineering. Pilar was a non-traditional student studying biomedical engineering almost ten years after she left her original veterinary program. Pilar's age as well as her complicated path to engineering significantly differentiated the majority of her responses from other participants in the normative group. Indeed, it is remarkable that commonalities emerged between Pilar and the rest of the more traditional students within the normative group. Pilar connected her interest in biomedical engineering to her interest in animals, which stemmed from her experiences with her father's veterinary clinic. Pilar also viewed her family as being generally inclined towards science and mathematics, fields which she related to engineering in her interview. Notwithstanding her lack of a singularly influential individual, Pilar viewed her family as having provided her with a background of experiences that helped influence her choice to pursue engineering.

B. Grit

Grit has recently become a popular topic in engineering education research. Grit is defined as a student's passion for particular long-term goals coupled with the motivation to achieve those goals. This strong interest is also coupled with a perseverance of effort that allows students to overcome obstacles or challenges to obtaining a particular goal [38]. There are two big reasons this concept has become so popular. One, grit predicts success more reliably than intellect or talent, and two, it has been proposed as a concept that can be learned or developed [39].

Studies of grit in engineering have found some results consistent with research in higher education. One study showed that female engineering students have measurably higher levels of grit than their male peers [40]. This finding is not surprising as it would seem that it takes grit to be in a field that rewards masculine norms. Another study found no differences in grit for first-generation students and continuing education students [41]. Other work has criticized grit as "privileged," indicating that measurement of grit does not take into account the wider social context for students and structural forces in education systems that do not allow for grittiness [42]. In this work, we use the concept of grit within engineering education to understand student narratives related to how they navigate their pathways in engineering. This theoretical construct emerged as important to engineering pathways through students' descriptions of "what it takes" to be an engineer. We explore this idea in the context of our interviews, and how it may contribute to student persistence.

When asked about what an engineer needs to succeed and whether each participant had the required traits or skills to do engineering, the recurring message from the participants was one of enduring motivation or interest, and a determination to succeed with persistence of effort, the components of grit described by Duckworth [43]. However, where Duckworth and other researchers characterized grit as a generalized trait [43], our data suggests students have developed discipline-focused grit (i.e., engineering grit).

This result is similar to previous results in engineering that show that engineering students view grit as a task-specific construct [44]. Students believed that being gritty in other aspects of life was irrelevant if their persistence of effort and consistency of interest were not aligned with pursuing a degree or career in engineering. Students promoted the idea that having this sort of drive and determination with regards to engineering was critical for anyone who wanted to be an engineer and also that they themselves possessed these traits. Kathie, in particular, was confident about her "drive" to do engineering and immediately made the connection that drive allows engineers to do "pretty much everything" if coupled with time and effort. However, mentalities like this one may privilege particular circumstances like that of full-time, fully supported students, whose time and effort may be at lower opportunity costs than that of self-supported students or students who are supporting families.

These results are also consistent with research that describes the culture of engineering as "technocratic" [6], that is, a culture that values technical knowledge as well as success based on ability. Prior work has shown that students regularly describe engineering as "hard" and place themselves and the discipline of engineering as superior to others [45]. This belief may be advantageous to normative students' motivation and sense of belonging as even facing academic struggles would confirm positive expectations of hardness and required effort. While our findings do not show particularly new ideas with respect to grit, they help us understand how students conceptualize the role that grit plays in their success in engineering. Normative students seem to buy in to the cultural norms of engineering, which include the idea that one must have grit to succeed. Understanding the nature of these cultural norms can inform the process of changing attitudes that could drive away non-normative individuals.

C. The Intersection of Social Capital and Grit

Our findings suggest that students with engineering mentors are better prepared for the culture of engineering. Exposure to engineering and encouragement from influential relationships prior to entering college both bolstered the interest and motivation of students as well as set expectations for engineering behaviors. Interestingly, our normative participants widely reflected both access to engineering resources and possession of engineering grit. Despite explicit descriptions of influential engineering opportunities and individuals, these participants credited their engineering identities and expected engineering success to drive, determination, and hard work. While this belief may be welcomed in the culture of engineering and may further improve their social networks, it minimizes the importance of having particular prior experiences and the advantages of social support.

For instance, even though Dominic plainly considers advantages for students due to "how [their] mind works" or "gifts that [they] were born with," he proceeds to invalidate these statements by certifying the only necessity is a "want to do it." The normative group, with few exceptions, does not seem to link their general discussions of ideas and advantages one could be born with to their own social support structures. Specifically, the intersection of social capital and grit in normative students could be a dangerous combination if it leads to unproductive and negative perceptions of attitudinally diverse peers or those perceived to be untalented or struggling. Additionally, failure to utilize resources and pass classes may be seen by the normative group, and subsequently the engineering culture they contribute to, as the fault of the student who simply did not work hard enough.

Students may not have discussed this inconsistency in their interviews for a variety of reasons, such as only reflecting on these experiences for the first time, or having a true belief that the engineering field rewards those who work and have talent equally. Despite potential reasons for this lack of acknowledgment, these voiced beliefs reinforce the culture of engineering being a perfect meritocracy where those who have the skills and are willing are guaranteed to succeed. Failure in such a system, therefore, becomes the burden of the individual and is seen as the student's inadequacy (i.e., lacking the motivation for the hard work required) rather than being reflective of any potential systemic differences or barriers that produce inequities. Our findings point to reasons why students without these particular privileges may not enter or succeed in engineering culture, as they have neither the experience nor support from their peers to persist as assuredly.

Alternatively, the belief expressed by a couple of our participants that some skills cannot be taught or learned may also be partly reflective of social resources, or a lack thereof. While Kathie communicates that anybody can learn "technical skills" or otherwise valued engineering traits, she coincidentally, and perhaps ironically, describes "people skills," "ethics," and "how to be a good leader" as natural or inherent knowledge. Perhaps the cultures of engineering, as enacted by its members, does not sufficiently attract individuals from these backgrounds or provide avenues for existing students to develop these skills within the context of engineering.

VI. Implications

This work further emphasizes the beneficial impacts of encouragement towards and exposure to engineering by role models prior to college. All of the participants in this study had significant social resources in engineering, science, or math; all but one explicitly reported specific individuals who promoted engineering. As educators, it is gratifying that our participants did report teachers as having an impact on their decisions to pursue engineering. Finding ways to provide exposure to and support for engineering careers for students is an important key to diversifying the engineering field.

The universally-noted idea of "hard work" in engineering success should be examined critically, in light of persistent under-representation in several engineering disciplines. The benefits of grit do not outweigh the threat of overlooking students that are disproportionately marginalized from engineering studies due to factors other than their work ethic, technical skills, and interests. Further, interventions and classroom experiences that support the improvement of grit and grit-related traits should be considered carefully and openly to combat alienating side effects to potentially talented students.

Lastly, it is worth noting that our normative participants are surprisingly diverse in their demographic markers, while still belonging to the dominant attitudinal group. This demographic diversity without attitudinal diversity illustrates very clearly that as educators we can make no presumptions about the attitudes, preparedness, or quality of the engineering student population.

VII. Limitations and Future Work

Targeted emails to the normative group (convenience sampling) may have introduced a self-selection bias due to the omission of responses from participants that did not choose to volunteer for interviews. In the first interviews, participants informed researchers of their engineering backgrounds and histories. Thus, data gathered in this phase is, in part, retrospective. Naturally, subsequent interviews accordant with the larger study's sequential design will focus on the immediate academic experiences of students [46]. As these were first interviews, participant comfort with interviewing may have been limited, thus limiting the richness of the data collected. Additional interviews will build rapport between participants and interviewers, as well as offer opportunities for future clarification. The results of this study represent normative participants based on results from four American institutions. As such, the transferability of these results is limited and may not reflect global engineering contexts. However, this sample includes institutions with high international student enrollment, allowing us to reflect on the experiences of non-domestic students. Expanding these findings to other institutional contexts is needed to better understand trends in other American and international engineering programs.

More nuanced data may have been missed in analysis, due to the analytic method we selected compared to other choices (e.g., interpretative phenomenological analysis or grounded theory) [47]; nevertheless, our technique allowed for data-supported categories and themes, which were well-suited for exploring shared experiences between these students [29]. Lastly, the normative group was analyzed first for theme development. As such, not all themes presented in this paper are necessarily unique or exclusive to our normative participants. Ongoing work will allow for comparative analysis between normative and non-normative groups to understand how the different aspects of their attitudinal profiles interact with engineering culture.

VIII. Conclusions

We present one phase of a larger study that seeks to describe the ways in which engineering students navigate engineering cultures and develop engineering identities. Our qualitative analysis of attitudinally normative students reveals two significant themes. First, social resources influenced students' decisions to pursue engineering majors; these social influences include early engineering opportunities and role models. Second, success in engineering requires drive and persistence, or grit. Our participants describe grit as essential while simultaneously claiming all types of students are welcome and capable of succeeding in engineering. If students believe that anyone can do engineering with enough effort, they may perceive struggling peers, and potentially themselves, as not working hard enough rather than lacking accrued resources. These findings call into question the messages that are conveyed to students about what it means to be a successful engineer and describe the ways in which normative engineering students navigate engineering culture through the combination of early exposure and force of will.

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