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Using Think-Aloud Activities to Surface Women of Color's Perceptions of Engineering Culture (Work in Progress)

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Introduction

Undergraduate engineering is an environment of socialization [1] molding engineers through curriculum, policies, support services, student organizations, and job opportunities [2], [3]. This socialization process includes norms and beliefs that shape undergraduate engineering cultures [4], [5], [6].

One way to better understand the cultures of engineering is to surface perceptions of those who participate in the environment. Understanding perceptions can be particularly useful when an environment's culture impacts its inhabitants differently [7]. In engineering, this difference is particularly noticeable for women of color, who face mistreatment or are marginalized on the basis of race and gender [8]. Unsurprisingly, typical approaches to engage marginalized students in reflections on engineering culture seldom have students grapple with culture beyond the dimensions of race, ethnicity, and gender [9], [10], [11], [12], [13], [14].

Despite interest in surfacing perceptions, it is still difficult to elicit people's perceptions of an environment because they are not always consciously aware of the culture around them or how it affects them [15]. Accordingly, innovative approaches are required to help people reflect on their cultural surroundings and surface their perceptions of culture. Phenomenography offers promise as an avenue for surfacing perceptions. The methodology's purpose is to surface the different ways of perceiving and/or experiencing a phenomenon [16], where perception and experience can be viewed interchangeably [17]. Phenomenography is typically used to uncover the maximum variation in experiencing a learning phenomenon [18]; however, it has also been used to surface perceptions of phenomenon beyond conceptual understanding (e.g., [19]). To surface these perceptions, researchers often use think-aloud, also called talk-aloud, activities to collect phenomenographic data (e.g., [19], [20]). Think-aloud activities can reveal complex cognitive processes [21] that are hard to surface from dialogue alone [22].

As part of phenomenographic dissertation work, we designed two think-aloud activities, within a semi-structured interview, to surface women of color's perceptions of undergraduate engineering culture. In these activities, we engaged 24 women of color in reflections of engineering culture beyond race and gender. In this paper, we detail the development and implementation of both activities, providing sufficient detail for those interested in replicating them in their own context. We also share a high-level summary of the data we gathered using the activities and discuss the utility of these activities for phenomenography and culture research.

Interview Methods

In this section, we elucidate the interview sections of Author 1's dissertation's interview protocol relevant to conducting a phenomenography on the qualitatively different perceptions of undergraduate women of color on the cultures of undergraduate engineering. In this section, we use the first-person pronoun "I." When used, this pronoun refers to Author 1 and indicates steps carried out solely by Author 1 for her dissertation.

Context

I conducted semi-structured interviews with three pilot participants and 24 study participants. Piloting is essential in phenomenography to identify ways to improve alignment between the interview protocol and surfacing perceptions of the phenomenon of interest [16]. My pilot interviews were instrumental in informing the interview design used in the study, which is discussed in detail in the forthcoming sections.

Involvement List

To be considered for the study, participants completed a screening questionnaire about their demographic information, undergraduate engineering involvement [23], and perceptions of engineering culture. The primary purpose of this screening questionnaire was to identify participants who met the inclusion criteria (e.g., non first-year undergraduate women of color in engineering) across a range of institutions, identities, and perceptions. I updated the screening questionnaire items related to the perception of engineering culture after the first pilot interview to align the cultural element definitions in the screening questionnaire and the ones shown in the interview.

The screening questionnaire was also notable because it led to the co-construction of an involvement list. As part of the semi-structured interview, I co-constructed an involvement list with each participant to scope the interview to undergraduate engineering spaces at their institution, copying the list of opportunities they selected as being involved in during the screening questionnaire. This list of options they selected from [23] in the screening questionnaire is in Appendix A. I put this list in Zoom chat during the interview, and then asked them to tell me the specific names of items (e.g., SWE for identity-based student organization). I updated the first list with the names they shared and put this updated list in the Zoom chat. I told them this list captured their involvement in undergraduate engineering at their institution and instructed them to discuss only examples from that list for the rest of the interview. I used their involvement list to scope the conversation to the undergraduate engineering culture specifically. The first pilot interview revealed that it was necessary to scope the conversation with a tangible list.

Development of Activity 1

In the first think-aloud activity, I presented participants with a list of values and asked them to engage with these values in the context of undergraduate engineering. I updated the list of values and the prompt for what they were to do with those values based on my three pilot interviews.

Value List

In the first version of activity 1, I asked participants to identify the top ten values that they believed aligned most with engineering from a list of 117 positive values aggregated by [24]. After doing one pilot interview with this approach, I realized that I was inadvertently steering students' perceptions of engineering culture in one direction: positive. Because I was interested in surfacing a range of perspectives instead, I realized I needed to include both positive and negative words in my value list. I identified a new list of constructive and destructive value words from [25]. The original list has 220 words. I reviewed the list, removed words that did not make sense in the context of this activity (e.g., insult, chastity), and identified the clearest word from synonym pairs. From this process, I created a new list of 192 words. I reviewed this list and shortlisted 81 words that spanned a range of meanings and tones. These 81 words became the final value list, composed of 47 constructive or positive values and 34 destructive or negative values. This value list is presented in Appendix B.

As a result of the pilot interviews, I made several changes to the activity. After my first two pilot interviews, I realized that students were having trouble identifying 10 value words to discuss in the context of engineering. I changed the task to identifying 5-7 value words, which was more easily achievable for students. In the third pilot interview, my participant selected five words. I also updated how the value list was accessed during the interview. During my first two pilot interviews, I shared the value list with participants via a link to a PDF containing the words. This approach was limited because participants could not interact with the list. To better support a think-aloud process, for the remaining interviews, I pasted value words into a document that participants could access, so they could annotate the list as they thought through their selections. As a result of the pilot participants' confusion about the prompt, I updated it to clearly communicate the purpose the value words were supposed to serve in their response. The final prompt was: "Identify the top five to seven values that you believe undergraduate engineering values most."

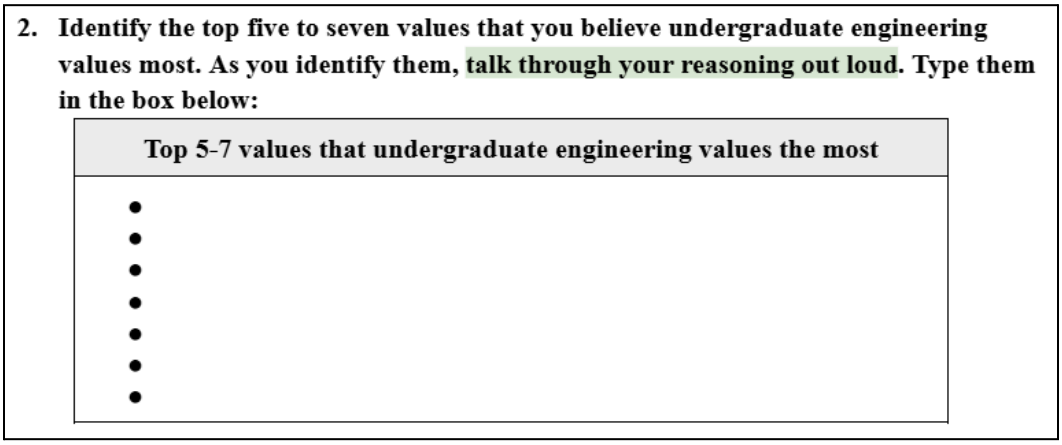
Activity 1 Walkthrough

Now I will describe Activity 1 from start to finish. I started the activity by reminding the participant that there were no right or wrong answers. Then I shared a Google Doc link with them in the Zoom chat. The Google Doc is where they filled out their answers to the activities. The first prompt of activity 1, typed on the Google Doc was "Take a look at this list of values and identify the top five to seven values that you believe undergraduate engineering values most (type them below on the next page)." The list of values participants saw is in Appendix B.

The second prompt was “Identify the top five to seven values that you believe undergraduate engineering values most. As you identify them, talk through your reasoning out loud. Type them in the box below.” This prompt and what participants saw are shared in Figure 1.

Figure 1

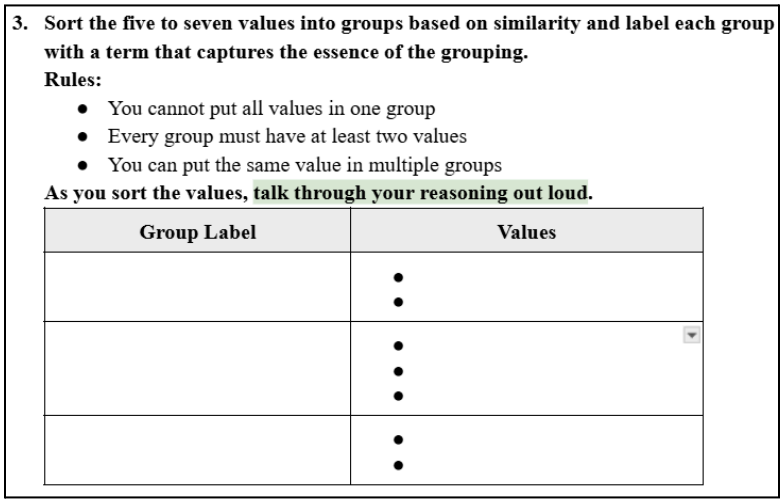
Activity 1 Prompt 2



As participants wrote their words in the box, I asked them to explain what the value word meant to them and how they knew that engineering valued that concept. Then, in the second part of this activity, I asked participants to sort their value words into groups based on their similarity and label each group with a term or phrase. This subactivity and what participants saw are shown in Figure 2.

Figure 2

Activity 1 Prompt 3



Once the participant created their groups, I asked them to explain the relationship between the words they grouped and the group label. If they struggled to determine a group label, I co-constructed the label with them based on their explanation of the relationships among the value words.

To conclude this activity, I asked two more questions: 1) Which of these values do you like about engineering or consider positive, and which of these values do you dislike about engineering or consider negative?; and 2) Look at the list of engineering spaces we created earlier, in the Zoom chat. For these spaces you are involved in, are there any spaces that embody different values than the 5-7 values you chose earlier? What are they and why?

Development of Activity 2

In the second think-aloud activity, I asked participants to explain how well each of the following ideological norms represented their undergraduate engineering environment: depoliticization, technical social dualism, meritocracy, competition, individualism, masculinity, and whiteness.

In the first version of this activity during the first pilot interview, I asked the participant to "rank the elements of engineering culture from highest to lowest in terms of how much you think they define engineering in your major at your institution." Then I planned to ask, "Tell me about a time when you encountered each of the following in engineering in your major at your institution?" but did not have time to go through an example for each.

After the first two pilot interviews, I entirely updated the activity task. The final prompt was "Sort the elements of engineering culture into how well you think they represent engineering, from what you have seen. As you sort the elements, talk through your reasoning out loud."

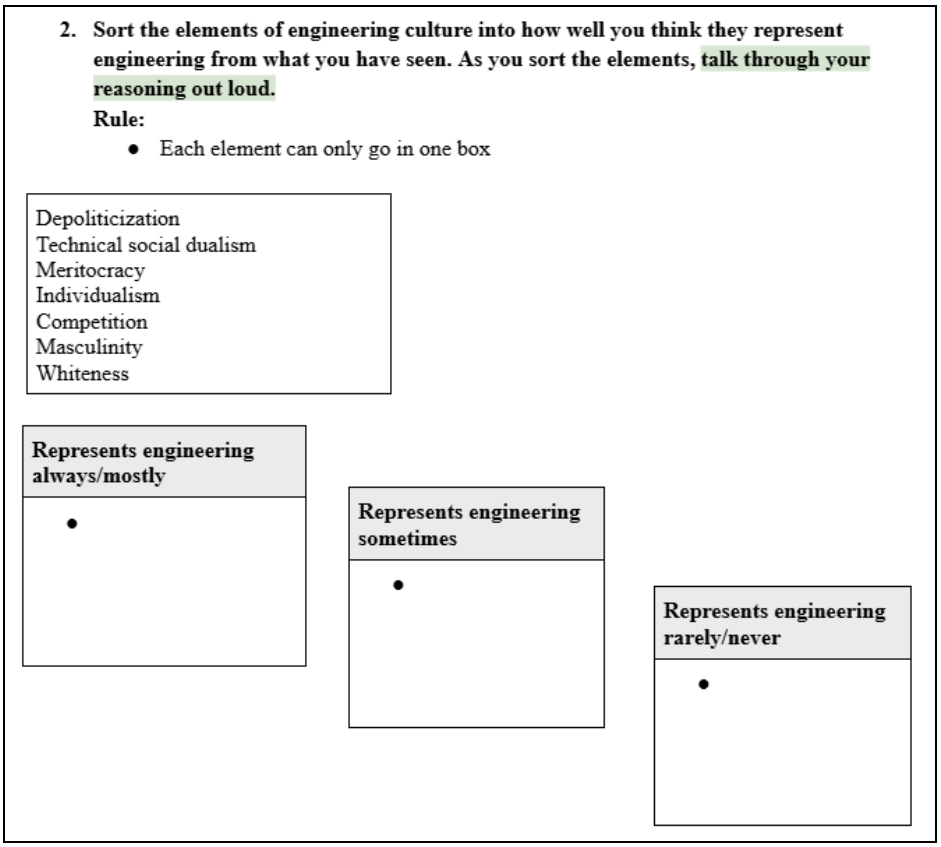
Activity 2 Walkthrough

Now I will describe Activity 2 from start to finish. I started the activity by reminding the participant that there were no right or wrong answers. Then I prompted them to open the second tab in the Google Doc. The first prompt for this activity was: "Engineering has been traditionally described with certain traits by engineering education researchers. Take a moment to review the engineering culture norms and their definitions." These culture norms and their definitions are provided in Appendix C. We developed these culture element definitions by synthesizing research on engineering culture. Once the participant finished reviewing the terms and their definitions, I clarified any questions they had about the definitions.

The participant then completed the sorting activity, placing each element of engineering culture into one of three boxes: represents engineering always/mostly, represents engineering sometimes, or represents engineering rarely/never, as shown in Figure 3.

Figure 3

Activity 2 Prompt 2



As the participant placed one element at a time into a box, I asked them to explain their placement, using examples from their involvement list.

To conclude this activity, I asked two more questions that were similar to the questions at the end of Activity 1: 1) Which of these elements do you like about engineering or consider positive and which of these elements do you dislike about engineering or consider them negative?; and 2) Look at the list of engineering spaces we created earlier, in the zoom chat. For these spaces you are involved in, are there any spaces that misalign with how you placed the culture norms? What are they and why?

Preliminary Findings

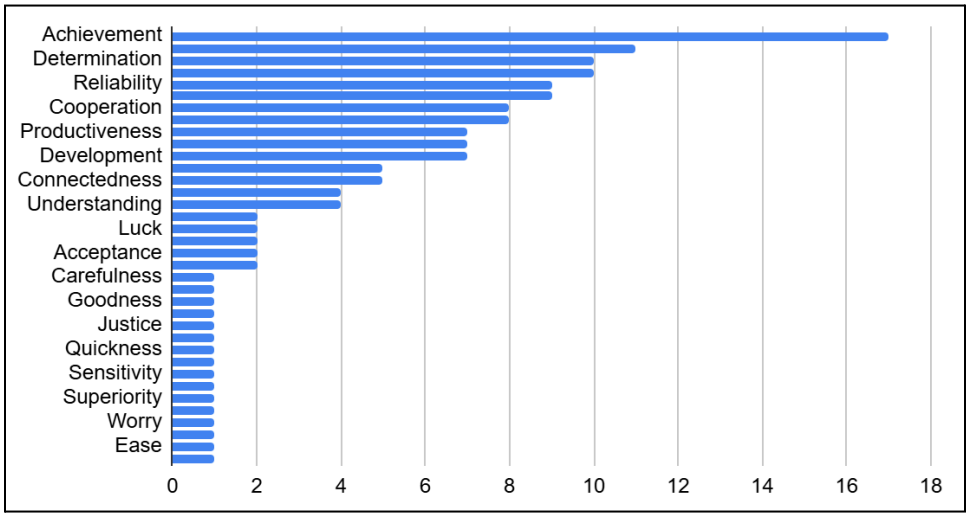
This paper is a work-in-progress because the findings presented here do not reflect the overall findings of the phenomenographic study [26]. Rather, these findings are a snapshot of the data gathered to illuminate the type of information we collected via think-aloud activities.

Preliminary findings from this study suggest that these think-aloud activities were effective at surfacing a range of students' perceptions of engineering culture. In Activity 1, participants selected 37 words from the 81-word value list, representing 45% of the list. 20 words (25%)

were selected by at least two participants, with four words (5%) being selected 10 or more times. Figure 4 shows the count of all selected value words.

Figure 4

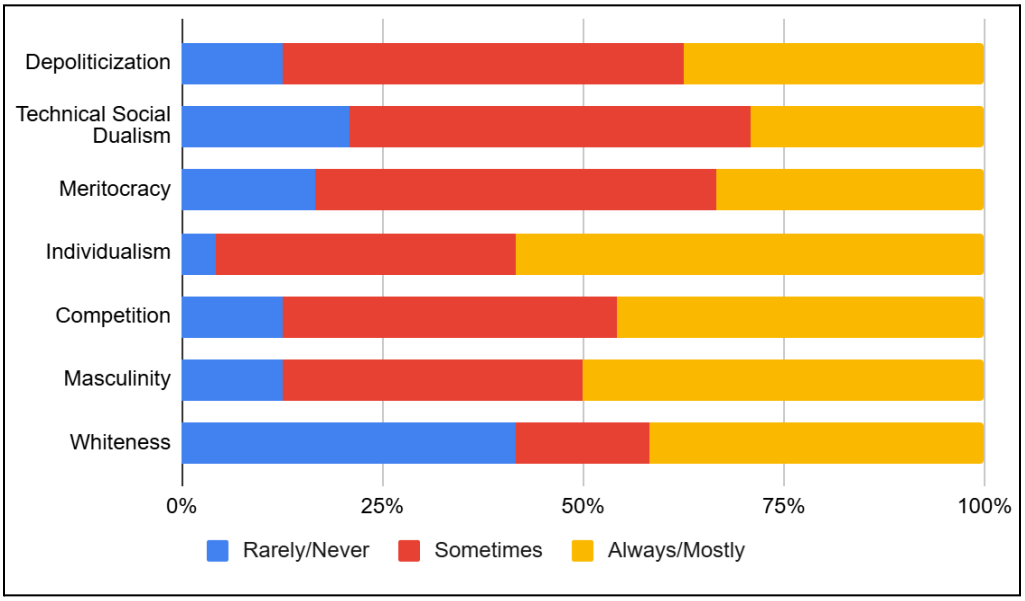
Count of All Selected Value Words



In Activity 2, all seven culture norms were placed in all three boxes across participants. Figure 5 shows the distribution of the placement of the culture norms.

Figure 5

Distribution of Perception of Culture Norms of Undergraduate Engineering



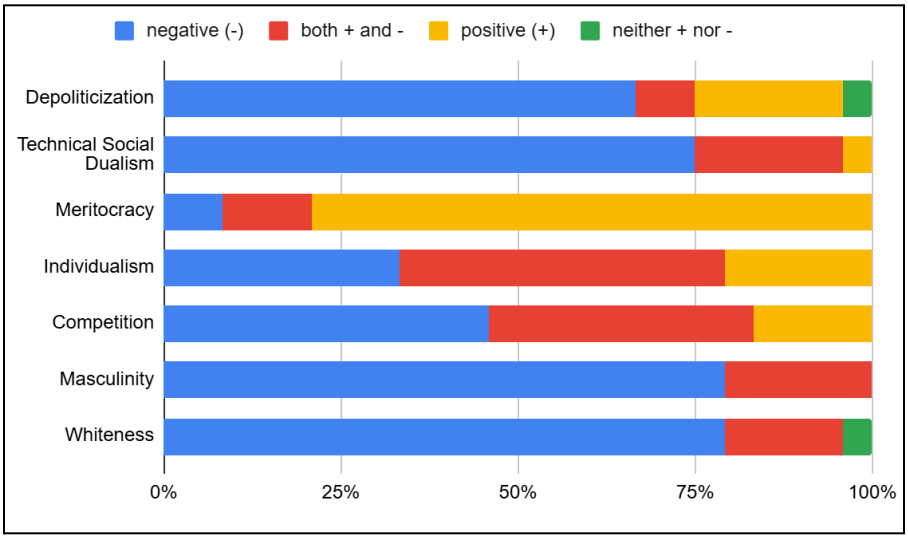
Whiteness was the most polarizing cultural element. An equivalent number of participants, 10 (41.7%), placed whiteness in the box “rarely/never represents engineering” and “always/mostly

represents engineering." For the culture norms besides whiteness, 9 to 12 participants (38% - 50%) placed the element in the box "sometimes represents engineering."

As for the valence assessment of the culture norms, there was far less distribution. A majority of participants identified whiteness (79%), masculinity (79%), technical social dualism (75%), and depoliticization (67%) as negative, shown in Figure 6.

Figure 6

Frequency of Valence of Culture Norms of Undergraduate Engineering



Competition and Individualism had the least valence consensus amongst participants. Between 37% and 46% of participants viewed individualism and competition in engineering as both positive and negative.

Limitations

Our approach has a few limitations. First, in the first activity, we primed participants in their reflection of engineering culture by providing them a list of values, rather than having them generate value words on their own. We asked them to select 5-7 words, which was less than 10% of the total list, so their options reflected a much wider range than their possible choices, reducing the priming impact.

During Activity 1 Part 3, I played an active role in helping participants construct value groups when they were unsure what to pick. This co-construction has an impact on the larger phenomenographic study, rather than the information presented in this paper. I mitigated this impact by analyzing students' explanations of the groups rather than words we chose to label the groups.

Finally, my recruitment methods ended up mostly identifying students who were very involved in their learning environment. Therefore, my findings are reflective of engaged students' perceptions of engineering culture, rather than all engineering students' perspectives broadly.

Utility of Think-Aloud Activities

Through this study, we have shown that think-aloud activities are useful for surfacing perceptions and cultural information.

We elicited participants' perceptions of undergraduate engineering culture without priming them through Activity 1. This result was especially useful within the methodology of phenomenography because it allowed us to identify a broad range of perceptions with high specificity, as participants could pick words from a list.

Activity 2 was valuable because it surfaced both quantitative and qualitative information simultaneously. This activity essentially mirrored a Likert scale. But rather than gather this information via a survey with no justifications for their choices, we were able to dig into their thinking immediately. An unintended benefit we found is that we could use participants' explanations to check their placement of the word. If the placement and explanation did not align, we could have a conversation with the participant and dive deeper into the tension. Also compared to a standard semi-structured interview, this approach was more systematic for revealing each participant's varied perspectives on one topic.

The combination of Activity 1 with Activity 2 was useful for soliciting new information (values in Activity 1) to inform updates to existing knowledge (culture norms in Activity 2). Specifically, we were able to identify confirmation of dominant narratives without directly asking about them through Activity 1. We were also able to identify cultures beyond the dominant narratives (i.e., achievement, collaboration, connectedness) because we did not prime them in Activity 1.

Compared to a traditional semi-structured interview, using think-aloud activities gave participants the opportunity to react to information in real time and then gave us researchers the ability to compare participant reactions to the same information afterwards. In standard semi-structured interviews, participants answer open-ended questions with little additional context. In our think-aloud activities, participants worked with information we provided them, reflecting in a guided and structured way.

<u>Process Learning</u>

This was our first time using think-aloud activities for a qualitative study, so we had some process learning as well. First, we originally had participants complete the activities entirely via Zoom chat. After the first pilot interview with this approach, we realized that Zoom chat

obscured the participant's thinking because we could not see live typing. It was also much more difficult to quickly capture notes from the Zoom chat.

Due to these limitations, we quickly changed our approach to a shared Google Doc. The Google Doc provided several affordances. For one, we could see what they were doing as they typed, which improved the amount of information we were getting (e.g., typing means *still thinking*). Additionally, we could easily scrape all the data from the Google Doc (e.g., values selected, value groups, placement of norms) after the interview, which was time-efficient. Finally, writing the rules in the Google Doc reduced the number of questions participants had because they could see the prompt and rules right in front of them. Fewer questions from participants meant more time for them to participate in the activities.

Conclusion

Think-aloud activities offer a lot of flexibility in how you collect data. Because you are fully in control of the format, you can allow your format to assist you. For example, we found that think-aloud activities can shift the power dynamics of the interview from dialogue to co-construction. Overall, we demonstrate that think-aloud activities are not only useful for phenomenography, in surfacing a range of perceptions, but they are also useful for prompting reflections on culture.

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Appendix A

Involvement List

1. Which of the following have you done since becoming a student at your current institution? [select all that apply]
    - Participated in an internship, co-op, or field/lab work
    - Attended a professional conference
    - Held a formal leadership role in a student organization or group
    - Participated in a living-learning community (e.g., theme-based dorm)
    - Participate in a summer transition program before my first semester at the university
    - Participated in a study abroad program
    - Conducted undergraduate research

2. During the current school year, how involved have you been in the following activities? [never, once or twice a semester, once a month, once a week, almost everyday]
    - An out-of-class student design project/competition
    - A STEM club or student chapter of a discipline-specific professional society (IEEE, ASME, ASCE, ACS, APS, etc.)
    - A STEM-club or student chapter of a professional society focused on underrepresented groups (e.g., NSBE, SHPE, SWE, NOGLSTP, oSTEM, SACNAS, NOBCChE etc.)
    - A STEM-related fraternity/ sorority or honor society (Theta Tau, Alpha Omega Epsilon, etc.)
    - A non-STEM social fraternity or sorority (CPC, IFC, NPHC, etc.)
    - A formal mentoring program as a mentor
    - A formal mentoring program as a mentee
    - Student government
    - Volunteering/outreach programs (service learning, EWB, etc.)

Adapted from [24]

Appendix B

Activity A - Value List

Positive and negative values in alphabetical order

Acceptance
Achievement
Alienation
Anxiety
Atrocity
Balance
Carefulness
Carelessness
Certainty
Comfort
Complexity
Compliance
Conformity
Confusion
Connectedness
Consistency
Contentment
Cooperation
Corruption
Determination
Development
Disagreeableness
Discretion
Discrimination
Disorder
Dullness
Ease
Failure
Flexibility
Foulness
Goodness
Hardness
Imperfection
Inadaptability
Inconsistency
Inferiority
Injustice
Justice
Luck
Misunderstanding
Naturalness
Nonacceptance
Noncooperation
Order
Overdevelopment
Overrefined
Perfection
Plainness
Pleasure
Power
Productiveness
Quickness
Quietness
Reasonableness
Reliability
Respect
Responsiveness
Self-sufficiency
Selfishness
Sensitivity
Simplicity
Sincerity
Smallness
Soundness
Stability
Sufficiency
Suitability
Superiority
Support
Tolerance
Unapproachable
Unclear
Understanding
Unfit
Uniformity
Unity
Unluckiness
Unnaturalness
Vileness
Weakness
Worry

Adapted from [25]

Appendix C

Activity B - Normative Element of Engineering Culture and their Definitions

Normative Element of Engineering Culture	Definition
Depoliticization	Engineering views political issues (such as housing insecurity, labor rights, or economic inequality) as not relevant to engineering content or practice.
Technical social dualism	Engineering values technical considerations (such as efficiency and cost effectiveness) more than social considerations (such as how a design may impact different people differently).
Meritocracy	Engineering success is based solely on student ability and effort, such that every student in engineering has equal opportunity to succeed regardless of their identities and background
Individualism	Engineering prioritizes students striving for individual achievement and excellence (such as good grades, access to opportunities, etc) over group achievement (such as team awards)
Competition	Engineering encourages students to outperform their peers and prove their abilities.
Masculinity	Engineering environments are overwhelmingly male-dominated, often portray men as leaders and women as supporters, and value dominance, assertiveness, emotional toughness, and risk taking.
Whiteness	Engineering knowledge and structures promote Western histories of innovation, obscure non-white histories of engineering, and portray White people as leaders and people of color as supporters.