Engineering as a challenging vocation: How students align personal values to the dominant engineering discourse

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Abstract

This paper presents the values that engineering students may deem important to their vocations. In addition, we sought to describe how the values system of engineering students may be reflective of the Discourses of engineering – ways of recognizing and being recognized as a member of a group by enacting distinctive ways of valuing, feeling, or believing among others. We analyzed students' responses using critical discourse analysis to investigate how language, as a form of social practice, is used among engineering students to conceptualize purpose. We argue that language in text used by students is descriptive of how they create meaning of different situations, and that those situations are reflective of the larger dominant discourse created by sociocultural practices in engineering. Preliminary results indicate that engineering Discourses may influence the conceptualizations of status, power, and solidarity in relationship to their values and vocations.

Introduction

The concept of vocation is sometimes ignored by engineering students given that its connotation is traditionally related to religious endeavors. However, examining vocation can provide a frame of reference for individuals that seek to live their authentic selves while engaging in a particular trade or profession, including those outside of religious settings. Vocational decisions involve not only thinking about a career, but also about the community, discourses, values, and relationships that encompass the quest for meaning and purpose in life. Thus, the integration of vocational education in engineering curricula can be very transformative for students as it encourages them to reflect on, and even reconcile, their values and their engineering identity. Research indicates that certain aspects of engineering education curricula, such as the depoliticization of engineering and the myth of meritocracy [1], can create conflicting interpretations of what it means to be an engineer and even promote a culture of disengagement [2].

The motivation behind this work began as we sought to incorporate exercises into our engineering courses to help students integrate their personal values with how they envision themselves as professional engineers. Research indicates that sometimes the personal values of students and their everyday experiences clash with the social norms and practices created by formal schooling [3]. These "cultural borders" exist for a variety of reasons and it is up to the instructors to act as "culture brokers" [4]; thus, we continued to foster the spaces where students could engage in conversations that acknowledged their everyday experiences. This work is well aligned with one of our main program outcomes which states that we seek to develop graduates who "have a critical awareness of their personal attitudes, behaviors and values and the ways in which these align with their professional aspirations" [5]. This program outcome is strongly

rooted within the values of our contemporary Catholic university, which emphasizes vocation. Specifically, on our campus, we adhere to Buechner's definition of vocation as, "the place where your deep gladness meets the world's deep needs" [6].

Despite these efforts, we recognize that the actions, social interactions, beliefs, values, and material world around the students may send a different message. These elements surrounding engineering spaces have constructed a particular narrative around engineering. Rather than acknowledging the personal values and material realities of students, engineering social practices have been characterized by the lack of acceptance of difference and an emphasis on academic survival [7], and the importance given to work that produces capital and material results [8]. Thus, the Discourse created around engineering—the things that are valued and acknowledged—may not align with students' personal values. Nonetheless, these Discourses may perpetuate the idea of how students see themselves as future engineers and how they may want to enact their personal values.

In an attempt to challenge students to critically reflect on their own personal values as well as how they envision these values meshing with their engineering identity, we had the students perform a "values card" activity while in a user-centered design course [9]. In this paper, we outline this activity, our data analysis methods, and an analysis of discourse in engineering.

Theoretical Framework

Discourse in Engineering

Discursive practices in engineering involve learning how to talk, think, act, and share common beliefs, values, and ways of being, knowing and doing. In this sense, socialization is crucial as a pathway to learning how to become and act as an engineer. As Lee [10] stated, "from the sociocultural perspective, learning science involves learning to think, talk, and act as a member of the science community. It also involves developing the values and beliefs shared in the science community" (p. 189). Socialization also becomes the vehicle through which students experience human phenomena related to learned behavior patterns distinctive of a culture such as the norms, values, beliefs, expectations, and conventional actions. Gee [11] described these actions as the enactment of a Discourse[1] the combination of language with other social practices such as behavior, values, ways of thinking and perspectives. Thus, engineering Discourse creates a standard for engineering students to learn what is expected of them in the profession.

In this context, engineering is not exclusively a cognitive process but it is embedded within Discourses, which include a set of social practices and tools. It is through these discursive practices that the construction of engineering knowledge is developed. Practices such as evaluating, assessing alternatives, considering trade-offs, interpreting texts or images are essential components of learning how to be an engineer. Nonetheless, an integral part of students' education toward becoming an engineer relies on the practices, beliefs, and values that

[1]Gee [11] differentiates between a capitalized D ("Discourse") to describe a set of practices and a lower case d ("discourse") to describe colloquial use.

are part of their everyday lives. Gee [11] described Discourse as the "distinctive ways of speaking/listening and often, too, writing/reading coupled with distinctive ways of acting, interacting, valuing, feeling, dressing, thinking, believing, with other people and with various objects, tools, and technologies, so as to enact specific socially recognizable identities engaged in specific socially recognizable activities" (p. 155). Thus, Discourse gives students their sense of self, what they do, and how they must act every day to fit in a particular culture (i.e., engineering).

Discourses are socially situated identities and highly influence the social context in which knowledge and certain practices materialize. Discourses influence how individuals practice and engage in different activities, including engineering. Based on Gee's [11] definition of Discourse, engineering can be described not only as a cognitive process but also as part of a larger engineering Discourse that is not separated from the cultural and social dimensions of engineering. The Discourses that students draw upon in their lives can be understood as a reflection of their identities.

When Discourse is entrenched in a particular field it can lead to detrimental effects. For example, Gilbert [12] explored how the Discourse of mechanical engineering valued the subordination of individuals to particular norms that led to gendered roles that reproduced the homosocial male world. Although a large body of research has addressed identity formation in engineering [13-15], more research on how Discourse mediates engagement, participation, and identification with engineering is necessary.

Other predominant discourses in engineering include particular ways of knowing, doing and being [7], no acceptance of difference [7], and a strong division of the "us" versus "them", primarily along racial and gender lines [16]. For instance, Godfrey & Parker [7] described how being logical, practical, conservative and not emotionally demonstrative were characteristics and values that engineers embraced as being indicative of who is an engineer or fits into an engineering subculture. In addition, the myths of meritocracy and objectivity [17] have created the assumption that only a few are "worthy" of becoming engineers, and that in order to be good engineers one must detach the object (i.e., the engineered artifact or the engineered world) from the subject (i.e., the engineer). This type of discourse obscures and reduces the impact and influence that engineers have on the artifacts they create and the decisions they make and how those influence society at large. These types of discourses perpetuate the idea that in order to become engineers one must fit a particular mold or align with the mythical norm of being white, physically able, an English speaker, and heterosexual [18, 19]. It is important to note that engineers may not be conscious of what is actually occurring when they adhere to these values, beliefs or behaviors (in the form of Discourses) because the dominant discourses do not name the multiplicity of discourses that define the nature and practice of the field. Moreover, there is little to no criticality when it comes to analyzing dominant discourses and how these serve only a few while disenfranchising many.

Discourse Analysis

Discourse analysis is a field that investigates how language is used in relation to particular social contexts. Some approaches to discourse analysis focus on spoken discourse, while others focus on written texts [20]. In this paper, we focus on a particular variant of discourse analysis developed by Fairclough [21-23] called critical discourse analysis (CDA). CDA focuses on how a particular discourse enacts, expresses, condones or reproduces inequality [21]. Fairclough [21] argued that discourses are a representation of social life, and can illustrate power dynamics, hegemony and relations of domination. It is through discourses that social issues are reflected and constructed, power relations negotiated, and social relations created and reproduced [24, 25].

Fairclough [21, 22] argued that critical discourse analysis provides a method to identify the hidden messages that may be present in different social structures. Meaning-making in this context involves creating, interpreting and delivering messages either through spoken or written texts. Thus, Discourse is interwoven with social practices and reproduced by culture and ideology [26].

Fairclough's approach involves a complex series of tools to perform detailed linguistic analysis (e.g., micro-level), as well as content and thematic analysis (e.g., macro-level) [21-23]. In this paper, we focus on thematic and content analysis to describe discourse in the larger scheme of engineering. We argue that, although our students receive an education that involves learning about other users, developing empathy, or learning about social justice, there exist pervasive discourses in engineering at the macro-level that impact how students see themselves as future engineers. Two particular concepts emerge from CDA that are important to the analysis presented in this paper of Discourse in engineering: nominalization and transitivity. Nominalization occurs when actors are not clearly involved in processes, or when there is a blurred line between an action and who performs that action [21, 24, 27]. For example, one of the participants in the study wrote "*contribution and mastery* are related around the effort and practice needed for me to be a good engineer." This sentence exemplifies a case of nominalization as it is not known who "contributes" or who makes the contribution for the student to be a good engineer. In fact, the student does not have an active role in becoming a "good engineer"; the student could very well imagine that their professor's contribution and mastery of content being taught is what will make the student a "good engineer." Although it can be inferred that the "effort and practice" will be enacted by the student, it is not explicitly stated if the student will have an agentic role. Overall, nominalization obscures who are the agentic actors and how actions will take place. Billig [28] argued that one of the important ideological functions of nominalization is to delete agency along with passivization.

On the other hand, transitivity focuses on events and processes that are connected with subjects and objects by providing a clear indication of who is involved in the action [21, 24, 27]. For example, one of the participants in the study wrote, "I want to be a compassionate, honest design engineer." This sentence demonstrates how the individual sees themselves as an agentic actor. The sentence also exemplifies a conscious action of becoming something very specific.

The concepts of nominalization and transitivity can be used to describe how individuals make sense of presence and abstraction and the social actors involved in everyday activities. In this paper, we use both nominalization and transitivity to describe how the participants conceptualize their personal values in actionable descriptions using written text. We focus on how students represent values as actionable items, who participated in those values/actions, and whether they see themselves as the agentic actors or use passivization to delete or minimize agency. The analysis of discourse using transitivity and nominalization is important to describe who is the actor, who has agency, and to describe–at the macro-level–whether or not the agentic actor included in the discourse is present or hidden. This approach also helps describe where agency resides, who is the person having agency, and who has the power to create change. As more engineering programs seek to instill in their students a sense of empathy and social justice, it is important to analyze how pervasive dominant discourses and the Discourse in engineering may collide with these efforts.

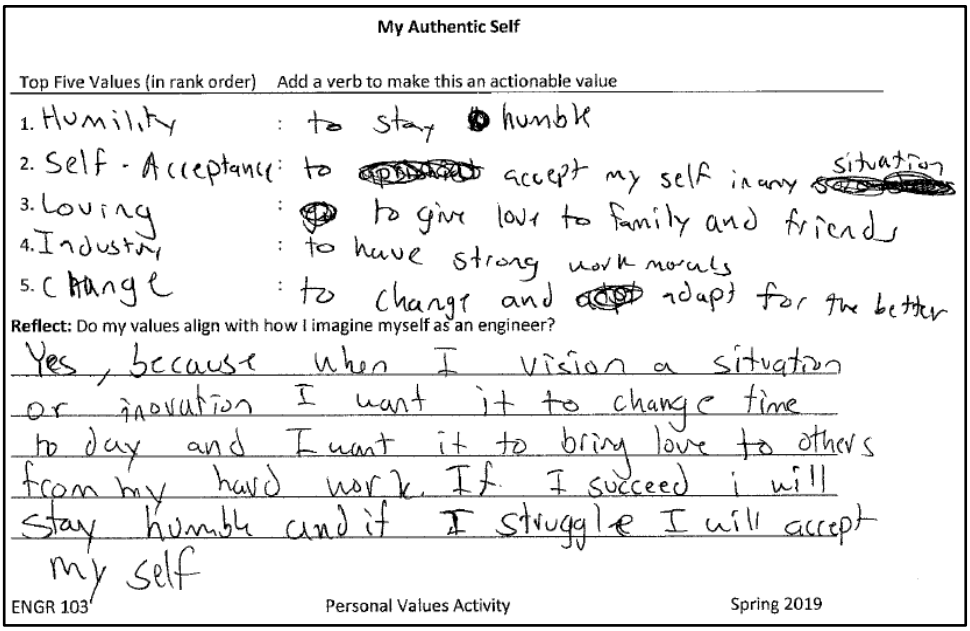
Methods

As one of our program's goals is to train engineering students to have a critical awareness of their personal attitudes, behaviors, and values, we conducted an in-class activity using "value cards" for students to reflect on their personal values. Our goal is to help students think early and deeply about how the ways they may want to live as a person may differ from how they are leading their lives as engineers. In this paper, we discuss 71 individual student responses collected from this activity during the Spring and Fall 2019 semesters. Each student was provided a deck of 83 cards with values on them [29]. The cards each have one value printed on them, such as *Authority*, *Fitness*, *Non-conformity*, *Responsibility*, *Self-acceptance*, and *Wealth*, followed by a short description of the value. For example, *Purpose* is followed by *to have meaning and direction in my life*.

Data collection

During this 30-minute activity, students first sort the deck of cards into three piles: *very important to me*, *important to me,* and *not important to me*. The *not important to me* pile is discarded, and the remaining cards are resorted into five or fewer groupings that resonate with the student. The students were instructed to create these groupings based on word similarities. Once the groupings were made, students chose one word from each group to label and represent the grouping.

Students were instructed to write these top values on the provided worksheet, as shown in Figure 1, and then add a verb to make their values actionable. For instance, *Act with mindfulness* was the example action provided for the value *Mindfulness,* as presented to students. Lastly, students responded open-endedly to the reflection question: "Do my values align with how I imagine myself as an engineer?" Students were encouraged to take photos of their responses to keep for themselves but were required to submit their anonymous activity slips.



My Authentic Self

Top Five Values (in rank order) Add a verb to make this an actionable value

1. Humility : to stay humble
2. Self-Acceptance : to accept my self in any situation
3. Loving : to give love to family and friends
4. Industry : to have strong work morals
5. Change : to change and adapt for the better

Reflect: Do my values align with how I imagine myself as an engineer?

Yes, because when I vision a situation or innovation I want it to change time to day and I want it to bring love to others from my hard work. If I succeed i will stay humble and if I struggle I will accept my self

ENGR 103 Personal Values Activity Spring 2019

Figure 1: Example of an anonymous student response on the provided activity worksheet

Data analysis

For all 71 activity slips collected, student responses were scanned, numbered, and transcribed into a spreadsheet for data analysis. For purposes of clarity, below we describe original information provided on the value cards in italics, while student responses are presented in quotes. We first conditioned the data by marking any non-standard response in the top values as *Other*. This included responses that provided more than one value in one line (e.g., "Passion or Knowledge"), or used value terms that were not provided in the original 83 cards (e.g., "Personality", "Privileges", etc.). In some cases where a simple misspelling or mistake was conceivable, we adapted the term to match the given value term. For example, "Life of adventure" was renamed as *Adventure*. In a handful of cases, we needed to more closely evaluate the action paired with the value to interpret the student's meaning. For example, there were several instances where we made a judgment call on whether the written value reflected *Loved* or *Loving* more closely. For example, one student's value response was "Love for everything", paired with an action of "love-giving"; we evaluated that the "love-giving" action better reflected a love for others (*Loving*) than the need to be loved by others (*Loved*). In rare cases, students' responses were evaluated alongside the other values and actions written on their slip. For example, while *either* "personal growth" or "career growth" could be recategorized as *Growth*, when one student wrote these phrases as two out of five of their final values, we decided to mark *both* values as *Other* rather than recategorize both as *Growth*, given that any value card should not have been used more than once. Once our data was cleaned to match the original 83 values provided, we calculated the frequency of occurrence for each value that was used by at least one student.

In addition, we analyzed the data collected using Fairclough's [21] method for critical discourse analysis. We primarily focused on content and thematic analysis, which involve the macro-level analysis aspects used by Fairclough [21, 22, 24]. We used the top five values identified by students and proceeded to individually categorize instances where nominalization and transitivity in their reflective texts was evident. We looked for evidence of first-person terminology (i.e., "I", "me", or "my") that clearly indicated the student expected their own involvement in their action phrase. We reached a 99% interrater reliability between two raters (authors 1 and 2) after only one iteration, and we reached 100% consensus after discussing only one action response that used the term "self". The results from this analysis are described in the next section.

Results

The full table of values and their frequencies obtained after data analysis are shown in Table 1 below. Figure 2 shows the percentage use of each value out of the total number of values submitted (351 total values across 71 analyzed slips). We chose to focus on the five values used most frequently by students as a representative sample for transitivity in their action phrases. While the *Other* category appears the most frequently, this represented data that could not be used in this study for reasons provided above and so is not used in our analysis.

The top five values, along with their frequency of occurrence and definition provided on the card, are as follows–with *Adventure* and *Growth* tied for fifth most frequent:

1. Family (21): to have a happy, loving family
2. Health (17): to be physically well and healthy
3. Purpose (15): to have meaning and direction in my life
4. Friendship (13): to have close, supportive friends
5. Adventure (11): to have new and exciting experiences
   Growth (11): to keep changing and growing

We extracted the 88 student responses that used these top five values to evaluate whether transitivity appeared in their associated action phrases. Out of the 88 responses, 26 responses (29.5%) indicated transitivity, while 62 responses (70.5%) did not. Table 2 below shows representative comparisons of nominalized and transitive action statements for shared values between student responses.

Table 1: Full list of values used with their frequency of occurrence and percent usage

Values	***Freq.***	***Percent***
Other	31	8.8%
Family	21	6.0%
Health	17	4.8%
Purpose	15	4.3%
Friendship	13	3.7%
Adventure	11	3.1%
Growth	11	3.1%
Passion	10	2.8%
Compassion	9	2.6%
Responsibility	9	2.6%
Contribution	8	2.3%
Excitement	8	2.3%
Loving	8	2.3%
Achievement	7	2.0%
Genuineness	7	2.0%
God's will	7	2.0%
Independence	7	2.0%
Loved	7	2.0%
Mastery	7	2.0%
Mindfulness	7	2.0%
Creativity	6	1.7%
Knowledge	6	1.7%
Pleasure	6	1.7%
Virtue	6	1.7%
Comfort	5	1.4%
Faithfulness	5	1.4%
Fun	5	1.4%
Honesty	5	1.4%
Industry	5	1.4%
Challenge	4	1.1%
Humor	4	1.1%
Inner peace	4	1.1%
Rationality	4	1.1%
Self-acceptance	4	1.1%
Caring	3	0.9%
Duty	3	0.9%
Ecology	3	0.9%
Hope	3	0.9%
Openness	3	0.9%
Self-Control	3	0.9%
Wealth	3	0.9%
Commitment	2	0.6%
Cooperation	2	0.6%
Dependability	2	0.6%
Fitness	2	0.6%
Intimacy	2	0.6%
Justice	2	0.6%
Leisure	2	0.6%
Realism	2	0.6%
Risk	2	0.6%
Service	2	0.6%
Spirituality	2	0.6%
Stability	2	0.6%
Acceptance	1	0.3%
Beauty	1	0.3%
Change	1	0.3%
Flexibility	1	0.3%
Forgiveness	1	0.3%
Generosity	1	0.3%
Helpfulness	1	0.3%
Humility	1	0.3%
Monogamy	1	0.3%
Order	1	0.3%
Popularity	1	0.3%
Power	1	0.3%
Self-esteem	1	0.3%
Self-knowledge	1	0.3%
Solitude	1	0.3%
Tolerance	1	0.3%
World peace	1	0.3%
Total	**351**	**100.0%**

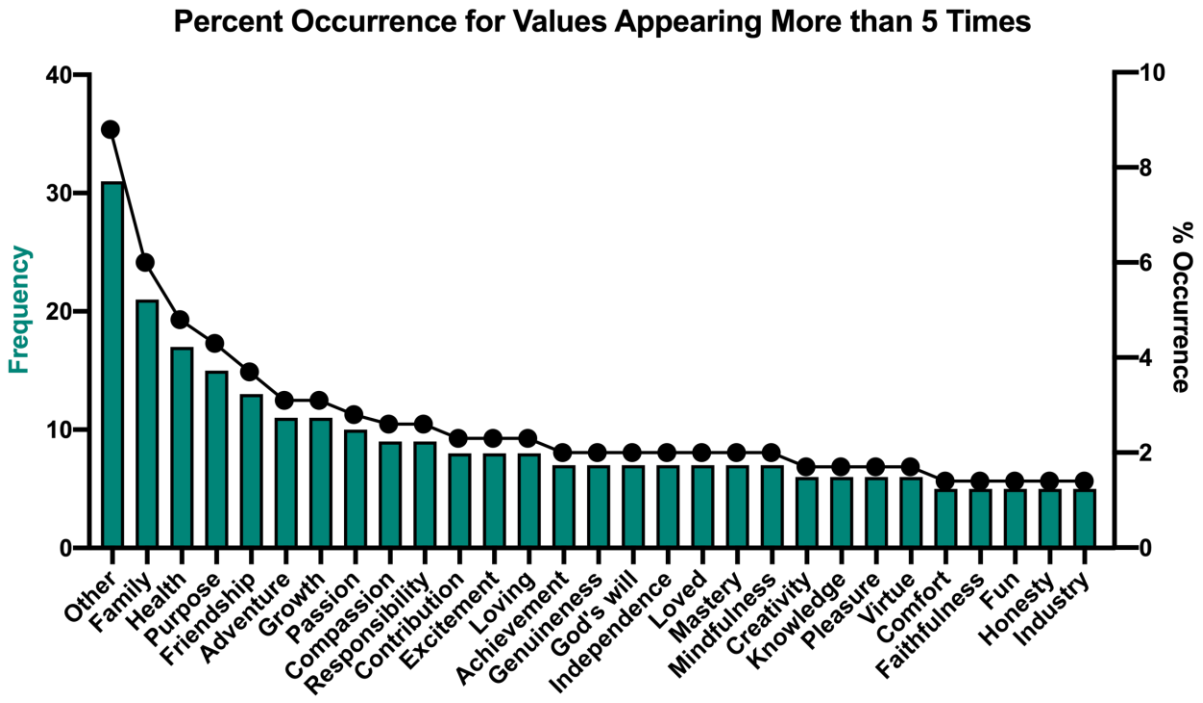


Figure 2: Percent occurrence of top values out of 351 total values used

Table 2: Student examples of nominalization and transitivity in their actionable values

Value	**Example of Nominalization**	**Example of Transitivity**
Adventure	"To live an adventurous life"	"Being adventurous in all I do"
Family	"Protect the family" "To create a family and support it physically and mentally"	"Love and protect my family" "Become a role model to my younger brothers"
Friends	"Have many close friends"	"I don't believe I could live a life without friends"

Discussion

Results indicated that students tended to align their values with particular engineering Discourses such as using nominalization to eliminate agency, reducing emotional demonstrations, and using passivization to minimize social consciousness. The representations of values included primarily transitive actions where the agentic actors were not described in detail. This effect could be due, in part, to the emphasis of engineering Discourses and discursive practices that emphasize

engineers must detach themselves as individuals from "objects" in an effort to be more neutral in their decision-making [17]. Thus, the myth of objectivity continues to be perpetuated through these Discourses. The results also show a tendency for students to not include themselves as agentic actors when it comes to emotional responses. For example, although values such as "friendship," "compassion," and "love" were among some of the most salient, students rarely included themselves as being part of the main actors on those actions.

Godfrey and Parker [7] argued that the engineering cultural dimensions – those that include "the values, beliefs and assumptions which underpin the culture of engineering education at the disciplinary, departmental, or institutional level" (p. 18) – have reinforced the idea that being not emotionally demonstrative is one of the qualities that engineers should possess. For instance, the examples of nominalization presented in Table 2 did not include any agentic actors. It is not known who does the action, or how the action takes place or in what context. As indicated by the students' actionable values, dominant Discourses in engineering continue to emphasize the idea that one must leave all emotions behind before stepping into an engineering space and placing themselves as subjects (e.g., actors). One detrimental impact of this Discourse is that those students that do not adhere to these unwritten rules of engineering could be perceived as unworthy or incapable of becoming engineers. Literature shows that this impact is primarily observed among female students and students of color [16, 30, 31].

In the rare instances that first person, singular pronouns (e.g., I, me, my) were used, they were usually followed by a familial actor (e.g., friend, brother, family). Some examples included "become a role model to my younger brothers" and "love and protect my family." These instances are indicative of how values are mostly connected to familial actors rather than other social actors, contexts, or situations that may be impacted by engineers (e.g., users, communities, consumers). Community and society were included or considered in the students' actionable values in very few cases, even though the course this activity was conducted in is designed to emphasize the importance of users and communities.

Also, students seemed to hold contradictory responses to their values, as they indicated that values such as "compassion" and "purpose" were of high importance but failed to include actors that are most affected by those values through engineering decisions. In other instances, their transitive actions focused on the self and were not necessarily reflective of developing empathy or a sense of social justice, which were two aspects the course emphasized throughout the semester. For example, one student responded, "I want to live life full of wealth and I want to value knowledge to the fullest." Other descriptions of transitive actions took a more tentative perspective, meaning that they interpreted their values as something that would contribute to their futures as engineers but did not necessarily see themselves as agentic actors that could create change. As one student pointed out, "I do not really know who I am as an engineer but I hope to uphold all of these things."

Billig [28] indicated that one of the emergent characteristics of nominalization was the ideological function of obscuring agency. The high number of instances where students described values without agentic actors is descriptive of the types of Discourses in which the students engaged. Freire and Macedo [32] stated discourses are used to read the world around us but also influence how we provide meaning and context to our surroundings. Removing agentic actors or disengaging themselves from actionable values may be indicative of how they use engineering Discourses to interpret and contextualize the world around them. Cech [1] indicated that students' awareness of social consciousness, where social agents are included, declines over time during students' engineering education. The emphasis on social consciousness continues to be an issue in engineering education that leads to a culture of disengagement [1]. It is important to consider how the culture of disengagement and the enactment of certain Discourses in engineering may influence how students "read the world" [32] around them and the ways in which these influence how they see themselves engaging in engineering practices, or live engineering as their true selves. The lack of a focus on the sociotechnical nature of engineering, or promoting the myth of objectivity [17], may influence how students see themselves as agentic actors in the spaces they occupy.

Limitations

One major limitation of our study that we recognize originates from the framework through which the value cards activity was introduced to students. In the step where we asked students to make their top five values actionable by adding a verb, the example we provided, *Act with mindfulness*, was non-transitive in nature. By using this non-transitive example as a representation of a good or acceptable response, we may have unintentionally led students to intentionally structure their own responses as non-transitive, indicating our own perpetuation of the culture of disengagement in engineering. It is important to note, however, that between the various sections and instructors, students may have received variability in the activity instructions. While the lecture slides that describe the activity were shared between classes, students who sought additional guidance on how to frame their values as actions may have received additional examples with nominalization demonstrated. Nonetheless, almost a third of the student responses from across the sections and across both semesters demonstrated transitivity in their actions, indicating the flexibility in instruction provided, as well as students' interpretation of how to conduct the activity according to their own values.

Another limitation of this study lies in not conducting follow-up interviews to more deeply investigate students' beliefs. Interviews may have allowed us to provide further discourse analysis on verbal responses where students could expand on reasons for their selected values. For instance, their non-transitive actions may have little to do with the culture of disengagement in engineering, as Cech [1] has documented. However, we decided to collect only the students' written responses, and we did so anonymously given the personal nature of the class activity. As

such, our analysis above is based only on the initial textual evidence created by the students. In light of this pilot data, we would consider expanding the activity to be non-anonymous in subsequent semesters to allow for follow-up interviews for future research.

However, even this limited data set and analysis reflects a larger context that we have observed in the classroom and throughout our curriculum. We have documented student resistance towards diversity, inclusion, and social justice topics [33]; acknowledging that engineering is a sociotechnical endeavor; and respecting the experiences of individuals (particularly people of color) [8] and product end-users that come from marginalized communities. Our results from this minor study align with our experiences of students pushing back against the fact that engineering decision-making is non-objective.

Conclusions

Engineering Discourses may contribute to the students' tendency to simplify or narrow down social aspects of engineering activity. While students may cherish certain values, it is important to question how engineering Discourses may perpetuate a culture of disengagement where students may perceive the need to distance themselves from the world around them to be more "objective." One example of how engineering Discourses perpetuate the culture of disengagement is the analysis of risk assessment. Students are taught to rely on data that indicates how "close" or "far enough" we are from an "ideal" model and use that information to make a decision. Nonetheless, the topic of moral judgment is rarely introduced in these decision-making processes. Although students think that risk assessment is based on data, the decision of whether or not that model is safe for people is based to some extent on moral judgment. This approach in engineering education may be counterproductive because it eliminates values and emotions that are used to make decisions. Thus, it is important to reframe how values are discussed in engineering classrooms and the impact that they have in influencing how engineers enact their actions.

Through an in-class values activity in an undergraduate engineering design course, we identified the core values that are important to engineering students. A critical discourse analysis of students' actionable value statements revealed a tendency for engineering students to distance themselves from these actions. Specifically, less than 30% of student responses included transitive action-statements. These results indicate that the existing engineering discourse of disengagement may influence how students relate to their own values and vocations. Given the limitations that we have identified above, future studies are needed that would further elaborate on students' thought processes during this values activity. One way to do this would be to conduct interviews with students following the values activity. Additionally, this work could be expanded to non-engineering students that are being trained in fields that are traditionally considered more transitive in nature, such as nursing students. Performing this activity with

nursing students could help to bolster our findings as we would expect to see a higher proportion of nursing students use transitive action-statements.

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