Work in Progress: Emotional Configurations in Undergraduate Engineering Education

Emily Kostolansky, Tufts University

Emily Kostolansky is a master's student in mechanical engineering at Tufts University. Her research interests in engineering education include undergraduate engineering education and emotions in engineering.

Dr. Kristen B Wendell, Tufts University

Kristen Wendell is Associate Professor of Mechanical Engineering and Adjunct Associate Professor of Education at Tufts University. Her research efforts at at the Center for Engineering Education and Outreach focus on supporting discourse and design practi

Nicole Alexandra Batrouny, Tufts University

Nicole Batrouny is a PhD candidate in Mechanical Engineering at Tufts University. Her engineering education research interests include upper elementary engineering education, integrated science and engineering, collaboration in engineering, and decision making.

Emotional Configurations in Undergraduate Engineering Education (Work in Progress)

Throughout the process of learning and doing engineering, there may arise many experiences that stimulate a breadth of emotions in learners and practitioners alike as they construct disciplinary knowledge, create physical artifacts, and navigate team dynamics [1], [2]. Positive affect and motivation have been proven to correlate with learners' ability and desire to engage in learning [3], [4]. Recent literature in the learning sciences expands on this evidence by positioning affect and motivation as epistemic [5]. That is, the emotions that engineers experience in the doing of engineering are themselves entangled with acts of building knowledge in engineering. By necessity, learning engineering must also attend to learning how one feels when doing engineering [6]. Therefore, the learning that undergraduate students engage in is an inherently emotional, or affective, process. For example, undergraduate students might experience frustration as they struggle to understand concepts, pride as they master a problem, or isolation as they navigate imposter syndrome.

However, experiences of epistemic affect can be complicated by the culture of engineering education. Scientific and engineering epistemologies are commonly described in the literature as objective, value-neutral, and depoliticized [7], [8], [9]. The construction of engineering education as objective implicitly devalues the subjectivity of emotions and their role in the doing and learning of engineering. This may pose consequences for undergraduate students as they experience, regulate, and react to complex emotions in and about their engineering education on a daily basis. For example, undergraduate students might be unprepared to process frustration about misunderstanding a concept, bond with their peers over a sense of pride, or seek out resources to combat isolation.

In this study, we designed a semi-structured interview protocol to explore undergraduate students' perceptions of emotion in their engineering education. We interviewed 20 mechanical and human factors engineering undergraduate students at a private university in the northeastern United States. We conducted a qualitative thematic analysis of interview data to address the following research question: *In what ways do emotions and learning intersect within the engineering education contexts of problem set sessions and makerspace project work?*

Conceptual Framework

This study is grounded in the emotional configurations perspective [10]. In this perspective, Vea positions emotion both as a part of sociocultural practices *and* as a sociocultural practice itself. In other words, humans learn the sociocultural practice of experiencing, expressing, and regulating emotions while our emotional experiences, expressions, and regulations are shaped by the other sociocultural practices that we partake in, like learning engineering. Drawing from the theory of sociocultural learning, Vea conceptualizes emotional configurations as the intersection between emotion, sense-making, and sociocultural practices in order to center the social, cultural, and conceptual meaning embedded in feeling. As sociocultural practices are subject to norms, ideologies, and power structures, so too are emotional configurations shaped by norms, ideologies, and power structures. In turn, emotional configurations have the capacity to shape these norms, ideologies, and power structures.

Data Collection and Analysis

The semi-structured interview protocol engaged undergraduate students in a matching activity between a set of 15 emotions and a set of eight contexts (four main contexts with two sub-contexts each), the majority of which were specific to the mechanical and human factors engineering program at the university (see Appendix). Interviews were initiated by presenting participants with the display of emotions, which were color-coded and grouped into eight categories. Participants were then presented with one context and asked to identify three emotions that they often experienced in this context. The interviewer asked open-ended follow-up questions to prompt participants to reflect on these emotions, repeating this process for all eight contexts.

We conducted and recorded hour-long interviews with 20 undergraduate students described in Table 1. We transcribed excerpts of interview recordings of four contexts: doing a problem set for Mechanics 1 alone, doing a problem set for Mechanics 1 with friends, making something in a makerspace for yourself, and making something in a makerspace for Electronics 1. The first author conducted line-by-line open coding [11] of three interview transcripts from a second-, third-, and fourth-year participant each, from which themes of emotional configurations developed organically. She shared the coded transcripts with her research group, who provided feedback on the coding scheme. In accordance with constant comparative analysis [12], she used this feedback to refine the coding scheme and applied it to the other seventeen transcripts. Finally, the second and third authors also reviewed several portions of her coding applications.

Table 1. Participant demographics

Engineering Major		Grade Level		Gender		Race and Ethnicity	
Mechanical	15	Second-year	7	Man	4	White or Caucasian and not Latine	10
Human Factors	5	Third-year	5	Woman	16	White or Caucasian and Latine	3
		Fourth-year	8			Asian and not Latine	3
						Asian and Latine	1
						Black or African American and not Latine	1
						Other and Latine	1
						Prefer not to say and Latine	1
Total	20						

Findings

We found that the students reported experiencing eleven distinct emotional configurations across the problem set and makerspace contexts. These configurations occurred in five clusters:

disciplinary ability, disciplinary identity, disciplinary engagement, disciplinary community, and *disciplinary self-consciousness*. Although these configurations were distinct, they often intersected with each other. Figure 1 illustrates that ten or more participants described experiencing ten emotional configurations. In other words, 50% or more of the participants described experiencing 91% of the emotional configurations. This demonstrates that emotional configurations were not an isolated phenomena among a few participants and provides evidence that emotional configurations may be common for many students in engineering education. Below, we define and describe examples of each emotional configuration.

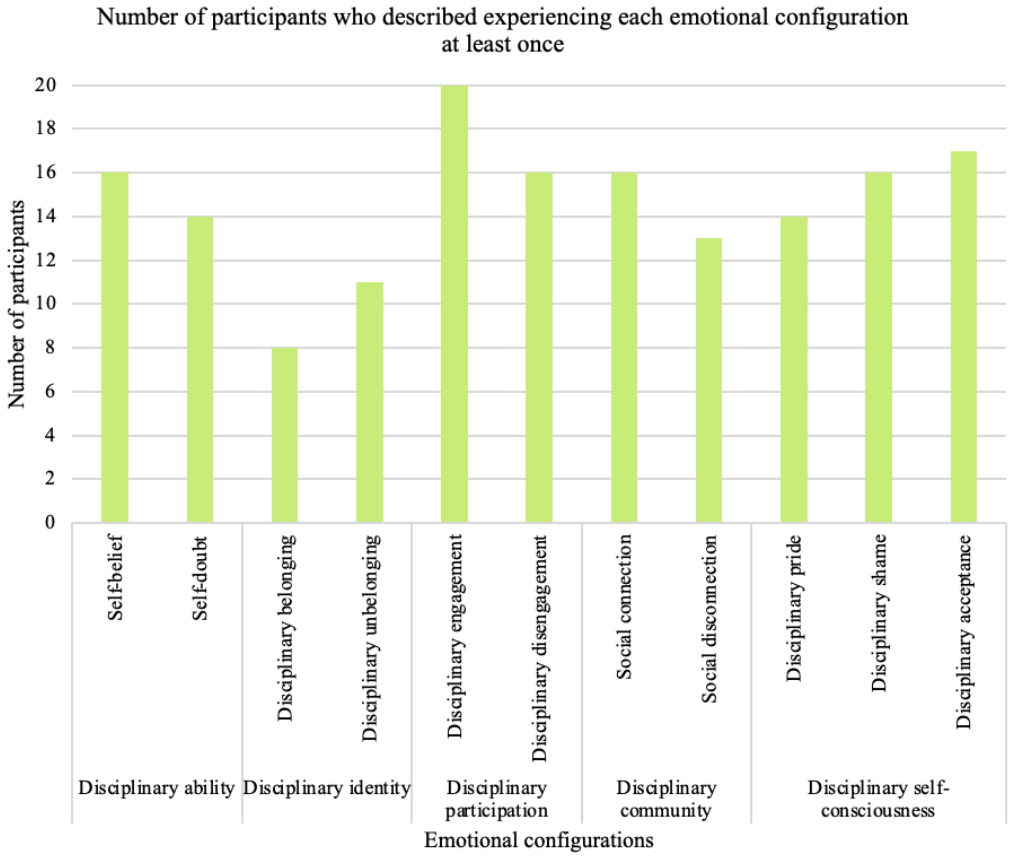

Figure 1. Number of participants who described experiencing each emotional configuration

Category 1. Disciplinary ability. Emotional configurations related to disciplinary ability emerged from students reflecting on their abilities as engineers, makers, learners, or students.
Self-belief. A student described experiencing self-belief when they expressed or implied that they felt competent as an engineer, maker, learner, or student, which often included a student using positive self-talk. For example, Emmeline expressed that she thought making a project in the campus makerspace "was so cool," leading her to wonder what project she should tackle next because she believed that she "can do so many other cool things in here."
Self-doubt. In contrast, a student described experiencing self-doubt when they expressed or implied that they doubted or wanted to doubt their competence as an engineer, maker, learner, or student, which often included a student using negative self-talk. For example, when Lavender

walked into the makerspace and saw "people…doing these super complicated advanced projects," she felt like she was "never going to be able to do anything like that."

Category 2. Disciplinary identity. Emotional configurations of disciplinary identity emerged from students reflecting on whether and how they recognized themselves within the engineering discipline.

Disciplinary belonging. A student described experiencing disciplinary belonging when they expressed or implied that they identified with, or wanted to identify with, the engineering discipline. This often included expressions of belonging in physical spaces associated with the engineering discipline, like makerspaces. For example, Nicolas shared that although it took him "some time to figure out (the laser cutter)," he felt a sense of excitement when using it because it mad him feel "like…I'm an engineer!"

Disciplinary unbelonging. In contrast, a student described experiencing disciplinary unbelonging when they expressed or implied that they did not identify with, or did not want to identify with, the engineering discipline. This often included expressions of unbelonging in makerspaces and other physical spaces associated with engineering. For example, Marietta shared that she was "nervous it was obvious [she] didn't know what she was doing" in the makerspace because she felt like she "didn't belong there."

Category 3. Disciplinary participation. Emotional configurations of disciplinary participation emerged from students reflecting on their investment in academic pursuits. These pursuits encompass both engineering practices and practices characteristic of higher education in general, although we recognize that these practices may not always align with each other [13].

Disciplinary engagement. When a student described experiencing disciplinary engagement, they expressed or implied that they felt invested or wanted to feel invested in academic pursuits, including motivating themselves, challenging themselves, or persevering in academic pursuits. For example, Delphi expressed that she has "more space to be curious…and learn more" when she doesn't "have this pressure of doing it perfectly."

Disciplinary disengagement. When a student described experiencing disciplinary disengagement, they expressed or implied that they withdrew or wanted to withdraw from academic pursuits, including avoiding or not challenging themselves to meet expectations on an academic pursuit. For example, Oliver expressed that he "let people take over" when he was building a project for robotics club "because [he] didn't want to embarrass [him]self."

Category 4. Disciplinary community. Emotional configurations of disciplinary community emerged from students reflecting on their connection with their engineering peers or instructors, like professors and teaching, learning, and course assistants.

Social connection. A student described experiencing social connection when they expressed or implied that they related positively or wanted to relate positively with their engineering peers or instructors, which often involved a student expressing a sense of community with their engineering peers. Penelope shared that she "realized that [the university] is like supportive and like, everyone is like there to help you" when she began to learn how to use tools in the makerspace.

Social disconnection. In contrast, a student described experiencing social disconnection when they expressed or implied that they disconnected or wanted to disconnect from their engineering peers or instructors. Angelina expressed social disconnection when she shared that she "felt left

out…like [she] wasn't a part of something" because her peers who were men dominated in the makerspace and she didn't "fit into that crowd."

Category 5. Disciplinary self-consciousness. Emotional configurations of disciplinary self-consciousness emerged from students reflecting on the relationship between a perceived success or failure in the engineering discipline and a perceived success or failure of themselves as an engineer, maker, learner, or student. Self-conscious emotions are associated with an individual's self-evaluation from their behavior in a given situation [14].

Disciplinary pride. When a student demonstrated disciplinary pride, they expressed or implied that they connected a perceived success in the engineering discipline to a perceived success of their engineering identity. For example, Marietta shared that "even when [she] was just like 3D printing," she experienced pride in her ability to make something, exclaiming "Oh, my god! I made this!"

Disciplinary shame. In contrast, a student exhibited disciplinary shame [15] when they expressed or implied that they connected a perceived failure in the engineering discipline to a perceived failure of their engineering identity. Andromeda described how she would experience shame if one of her projects didn't work because all of her peers would "see [her] like failing to put this together…and [she] should know what [she's] doing."

Disciplinary acceptance. A student demonstrated disciplinary acceptance when they expressed or implied that they disrupted the connection of a perceived failure in the engineering discipline to a perceived failure of their engineering identity. For example, when Andromeda reflected on a failed project, she expressed that although she was embarrassed because "this [was] not our project," she also recognized that failure "is part of the process."

Discussion

This qualitative analysis characterizes five categories of emotional configurations that undergraduate students experience in four contexts specific to their engineering education. These findings begin to demonstrate that learning to process emotions is an integral part of learning to do engineering that also shapes future learning opportunities within engineering education. It is also likely that gender, race, and ethnicity may shape the way that students may experience emotional configurations, particularly those within the disciplinary identity and disciplinary community categories [16].

Conclusion

These findings have implications for understanding how undergraduate students perceive the role of emotions in their engineering education and how educators can support undergraduate students as they experience, express, and regulate these emotions. Future work will explore how emotional configurations differ across contexts, grade levels, and participant identities within engineering education.

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Appendix

Interview Protocol

The majority of the interview will consist of a matching task designed to elicit participant reflection on the role of emotions in their engineering education. I will have a list of eight engineering education contexts (four main contexts with two sub-contexts each), which are specific to the mechanical and human factors engineering department of a private university in the northeastern United States.

Table 2. Four main contexts with two sub-contexts each

Talking about how your engineering classes are going		Attending a class section	
With family	With classmates	In English 1 (or another humanities, arts, or social sciences class)	In Materials 1 (or Calculus 1)
Doing a problem set for Mechanics 1 (or Physics 1)		Making something in the makerspace	
Alone	With friends	For yourself	For Electronics 1 (or Introduction to Engineering)

I will present participants with a display of 15 emotions, which will be color-coded and grouped into eight categories. The category titles will not be included.

Table 3. Fifteen emotions

Ecstasy	Admiration	Terror	Amazement
Happy Excited	Proud Relaxed	Afraid Stressed Nervous	Confused Uncertain
Grief	Loathing	Rage	Vigilance
Sad Embarrassed	Disgusted Bored	Angry Annoyed	Confident Curious

I will then present participants with a context and ask them to identify three emotions that they often experience in this context. I will also ask the participants to rank those emotions from most to least prominent. I will ask the participant to follow instructions like:

1. Take a moment to familiarize yourself with the emotions before you.
2. Take a moment to read the context aloud and think about what it means to you.
3. What three emotions do you often experience in this context?
4. Rank these emotions from most to least prominent.

I will ask open-ended follow-up questions to prompt the participants to reflect on the emotions they often experience in this context. I imagine that I will ask questions like:

- How did you experience these emotions in this engineering education context?
    - Can you tell me about a time that you felt that way?
    - Can you tell me about a time that you felt the opposite way?
    - What made you feel that way?
    - What did that emotion feel like to you?
    - What was going on when you felt that way?
    - Why do you think you felt that way?
    - Can you tell me more about why you felt that way?
- How did you express these emotions in this engineering education context?
    - How did you manage that feeling?
    - How did you express that emotion?
    - Why do you think you expressed that emotion?
    - How did other people respond when you conveyed that emotion?
    - What emotions did you see other people convey?
    - Can you tell me about a time that you could not convey that emotion?
    - What made you feel like you could not convey that emotion?
    - How did you feel when you could not express that feeling?
- Is there anything else you want to touch on before we move on?
- How do you understand the role of emotions in your engineering education?
    - How do you think your emotions influence your engineering education?
    - How much do you express your emotions in your engineering education?
    - How do you manage your emotions in your engineering education?
- Is there anything you would like to share about how you identify in terms of race, ethnicity, gender, or otherwise?

I will repeat this process for the eight contexts.