

Gendered Learning: How Constructs of Knowledge Impact Engineering Students' Sense of Belonging

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Abstract—This Work-in-Progress Research paper uses methods of narrative analysis and grounded theory to examine how engineering students make sense of their individual learning journeys through the process of narrating stories of their learning. In particular, we examine four engineering students' sense of belonging, and how emergent constructs of knowledge affect their belonging in the academic and workforce spaces they navigate. We identify three emergent types of knowledge: academic, relational, and emotional. Our analyses indicate that academic knowledge aligns with more masculine identities and forms of expression, while relational and emotional knowledge align with feminine identities and forms of expression. Emergent findings suggest that students may feel included or excluded from academic and workforce spaces based both on the kinds of knowledge they value and on their gendered identities.

Index Terms—learning journey, grounded theory, narrative analysis, belonging, knowledge

I. INTRODUCTION

Feminist epistemology scholarship [3], [4] interrogates the idea that the power assigned to scientific knowledge stems from the knowledge being “objective” truth; rather it points out that scientific knowledge is largely valued because it has historically been produced and controlled by men and is marked, or gendered, as “masculine” [3], [4]. Additionally, feminist ideas around “consciousness raising”—a concept that prioritizes personal experiences and was “conceived as a successor science with better truth-telling capacities” than “the already existent, male-produced knowledge, including scientific knowledge” [22]—pushes back against the supremacy of male-produced, scientific knowledge and the way it often minimizes room for and the perceived value of other forms of knowledge. Many scholars have theorized different forms of knowledge, such as logical-mathematical intelligence, interpersonal intelligence, subjective knowledge, and connected knowing [15], [6]. Similarly, in our study about engineering students' learning journeys, we investigate emergent constructs of academic, relational, and emotional knowledge, and the ways in which they might be gendered, affecting students' sense of belonging in certain spaces.

Current literature highlights that students must identify and be recognized by others as engineers to be successful. For example, Rodriguez, Lu, and Bartlett share their findings about the ways in which success, in the form of persistence in the field, is dependent on this sense of engineering identity and

recognition by others [25]. Women and other underrepresented groups in engineering may face difficulty in identifying with, being perceived as, and feeling welcome as engineers (see for example, [14]). Brucker, Price, Freeman, Goodman, and Zastavker find that achieving equality between numbers of men and women in engineering, academic environments does not ensure that everyone's experiences and learning outcomes are equitable, nor that everyone feels a sense of belonging in these environments [9]. Our study examines student experiences in a small engineering college with a relatively equal number of men and women. By investigating students' learning journeys, we identify factors that influence whether students identify with specific fields of study and, thus, feel a sense of belonging in or exclusion from those spaces. Specifically, we explore the kinds of knowledge, often gendered, valued by students and the institutions they navigate, and how these types of knowledge influence students' sense of belonging in those spaces.

Qualitative research methods have been slow to gain credibility in the field of engineering education [7], [8], [19], though they have long been considered useful in various other fields, such as psychology, sociology, and education research [13], [17], [11], [23], [10], [24], [20]. While many engineering education scholars express a desire to increase the rigor of engineering education research by incorporating qualitative methods into the field, some of those same scholars evaluate qualitative scholarship based on a quantitative framework [19], [7], [8]. This construct of “rigor” of qualitative versus quantitative work has also been given intentional consideration and we, as a community, “acknowledged the limitations of our previous focus on only quantitative research as being of high quality” [12]. Furthermore, we assert that qualitative and quantitative paradigms serve two different purposes, and qualitative scholarship should not be evaluated using criteria based on quantitative methods [8], [5]. Quantitative methods are primarily deductive, with narrow variables that are identified through a theoretical framework and then tested, and their purpose is generalizability to a broader population [19], [7], [8], [5]. Statistical significance, replicability, and large sample sizes are important to establish rigor in this paradigm. On the other hand, the purpose of qualitative studies is not generalizability—instead, qualitative methods offer complex, “thick,” and context-specific descriptions of

experiences through inductive means, usually with only a few participants. These rich descriptions can both identify previously unidentified phenomena and give insight into complexities not captured by quantitative measures [19], [7], [8], [5], [13], [17], [11], [23], [10], [24], [20]. In-depth qualitative measures, such as narrative analysis, also give voice to under-represented groups who have non-generalizable experiences [2], [12]. For instance, Adler examines the experiences of a single engineering student with a disability to gain insight on how her disability interacted with her identity development [2]. Furthermore, in another paper, Adler demonstrates that the way someone tells their story can influence their identity development and allow for the reflection on their positionality in the world [1]. Similarly, as the four participants in our study tell their stories of learning, they also come to a deeper understanding of both themselves and the forces that shape their identity. This narrative identity approach is particularly useful in engineering education scholarship, as it seeks to weave engineering students' unique experiences together in a way that can inform future work in multiple paradigms.

II. METHODS

The data sources for this pilot study include interviews with four undergraduate students (2 women and 2 men) from a range of class years from Celadon College, a small engineering school that boasts project-based, integrated, and team-oriented learning practices; all students obtain a degree in engineering (mechanical, electrical and computer, or general with possible concentrations in more specific engineering fields). The female-male student ratio is maintained at roughly 50-50 based on institutional records of legal sex. All names presented, including the name of the college, are pseudonyms.

Based on McAdams' life story interview protocol, this study employs a semi-structured, open-ended interview protocol that asks the students to describe their individual learning journeys [21]. We invite students to reflect on the following prompts: "If you were to write a book that describes a story of your learning, how would you structure it? What chapters would you want to include in this book? How would you name these chapters and what would you want to tell your readers in each of these chapters?" Participants are then asked to reflect on key learning moments in their journeys, including high and low point learning moments, a wisdom moment, a turning point moment, and a spiritual or mystical moment. Interviews range from 3 hours to more than 6 hours in length, with an average duration of 4 hours and 25 minutes.

We use methods of narrative analysis, qualitative content analysis, and grounded theory, to first write a series of descriptive and analytical memos and then to identify key emergent constructs and corresponding themes [16], [18]. Throughout the process, we repeatedly return to the interviews as a way of checking our emergent findings and performing internal checks among all three researchers about our interpretations, assumptions, and biases.

III. RESULTS AND DISCUSSION

Through their interview reflections, our study participants construct narratives of their learning journeys, which consist of individual stories that represent their chapters of learning and their key learning moments. One of the emergent themes in our preliminary analyses is students' sense of belonging. Narratives of belonging or exclusion dominate the stories of those students who perceive a sense of disconnect from their environments. Students share underlying reasons for their sense of not belonging, which, through narration of their stories, they attribute to aspects of their identity—being 'smart' or 'not smart,' being a woman, being queer. In comparison, when students feel a sense of belonging, they may fail to recognize aspects of their identity that inform this sense of belonging. We posit that when students feel a sense of exclusion from a space, they center their attention on the aspects of their identities they perceive as shutting them out from that space; for three of our participants, their gender or gender expression becomes central to their feelings of exclusion.

We find that students' feelings of belonging are influenced by their differing perceptions of what constitutes learning, and, correspondingly, knowledge. Thus, knowledge, with its corresponding types, emerges as another theme. Our analyses identify three emergent types of knowledge—academic, relational, and emotional. We find that the kinds of knowledge that students value are informed by their gender and gender expression—academic knowledge emerges as affiliated with a masculine identity and forms of expression, while participants seem to associate relational and emotional knowledge with a feminine identity and forms of expression. Importantly, we find that these types of knowledge interact in gendered ways: the men in our study perceive academic and relational/emotional knowledge as separate from and even oppositional to each other, while the women describe all forms of knowledge as interconnected. We also find that the students regard the academic and workplace environments they inhabit as valuing academic knowledge above other kinds of knowledge, impacting their sense of belonging in those institutions. For students who identify as women or express themselves in ways regarded as feminine, this valuing of academic knowledge, at the expense of relational and emotional knowledge, limits their sense of belonging in some academic spaces and propagates feelings of exclusion.

A. Identity and Belonging

Three of the four participants describe acute feelings of exclusion, especially in academic contexts, and look inward in an attempt to find the parts of themselves that fuel that exclusion—often one's gender identity or gender expression.

One participant, Amelia, a woman, explicitly ties her feelings of exclusion to her gender identity. For example, in her high school debate club, she discovers that "meritocracy was a joke" because, while some of her achievements are recognized, she often feels "pretty deprioritized compared to [her] debate partner who happened to be a guy" and is consistently assigned challenging speeches. She also notes that women debaters are

not usually considered “good at debate.” In addition to feeling socially excluded, Amelia is also physically left out of the debate space when her male teammates and coach forget to bring her – the only woman on the team – to a competition.

Jessica, another woman in our study, also speaks about feelings of exclusion as pervasive throughout her school experiences, though she does not assign her gender identity to be a primary reason for this exclusion. She does note, however briefly, that she felt out of place on her high school robotics team because she was the only girl. As an example, Jessica relates a memory of a father of one her teammates’ saying “Ladies first!” at mealtimes instead of letting her blend in with the rest of her team.

Both Jessica and Amelia share similar experiences in high school where they feel they don’t belong. They attribute this feeling to their perception of themselves as ‘not smart.’ Jessica relates an experience in a history class when her teacher told students not to study for a test. When Jessica followed his directions, she did poorly in comparison to her classmates, an unusual occurrence for her. This incident results in the realization that her “success in high school ... is really just all about the fact that [she] just work[s] insanely hard.” Amelia has a similar realization in high school. She describes her peers’ expectations of her as: “You’re a smart person, like school must be super easy for you.” These expectations clash with her reality of needing to work hard to earn better grades, and she asks “why was it harder for me than it was for other people?” Both women express a perceived incompatibility between hard work and smartness; Jessica refers to it as the “smart versus hard work conundrum.” We note that this theme, of not feeling ‘smart’ and thus not belonging in an academic space, emerges exclusively from the narratives of the two women participants. Both men describe a continued confidence in their own “smartness” or innate academic capability.

Julian, a white heterosexual man, stands apart from other participants as he never questions his place in academic or engineering settings. He notes that he “always thought of [him]self as a smart kid.” Additionally, Julian fails to mention his gender, sexuality, or race, seemingly unaware that those might have an effect on his comfort within academic settings. Rather, he describes regret about his high school’s consideration to include more of a “woman’s perspective or a non-white perspective” in their curriculum. While Julian notes that this is a worthy goal, he also declares that the curriculum worked well for him and that he hopes that “they don’t mess with what they have too much trying to incorporate these...new perspectives.” In this way, Julian remains seemingly blind to the possibility that the existing curriculum worked well for him because it is based on his shared dominant identities. His comfort and sense of belonging in academic settings is accompanied by a lack of awareness of the privilege his whiteness and male identity afford him in these spaces.

Tom, a queer man, describes themes of both belonging and exclusion from academic settings. He shares Julian’s confidence in his “smartness” while growing up; he notes that in high school he thought of himself as “one of the

smart kids who got into the smart kid classes.” However, he still describes feeling excluded from certain spaces, notably from his engineering college environment. Tom notes that these feelings of exclusion are at least partially attributable to his queerness and feminine gender expression; he “reject[s] masculinity in some ways that a lot of...[his] peers don’t” and his gender expression often “fall[s] into...non-masculine land.” Tom also shares a story about a college spring break trip, when he experienced a “big, deep crush” on another male student. This experience was transformative for Tom; he describes this discovery of his queer identity as “a door [that] opened up” to an exhilarating world where “change could play a significant role in [his] life.” Upon his return to Celadon, Tom faces an emotional crisis, realizing that “shit, there is no room for [queerness] here” because engineering is “a masculine thing.” Although Tom never feels excluded from academic and engineering spaces due to his “smartness,” or lack thereof, he feels excluded from engineering due to his sexuality and gender expression.

B. Knowledge and Gender

Through this emergent theme of belonging, we unearthed a second emergent theme related to learning and knowledge. Grounded in our interview data, we define three emergent types of knowledge: (i) academic: knowledge that is related to the traditional academic subjects and ways of learning predominant in traditional learning environments; (ii) relational: knowledge that is connected to learning about other people and oneself in relationship to others; and (iii) emotional: knowledge that is gained by processing one’s own and others’ affective states and emotions. We find that while academic knowledge emerges as an independent construct for some participants, relational and emotional knowledge are inextricably intertwined in students’ narratives. Thus, we merge them in this analysis into a single discussion. Our analyses reveal gendered patterns in the ways each participant values and legitimizes knowledge. Furthermore, the knowledge types are integrated into the participants’ holistic views of learning in different ways. For the men in the study, academic knowledge is often positioned as antithetical to relational and emotional knowledge, while the women perceive all three types of knowledge as intersecting. Finally, we find that institutions valuing different types of knowledge can foster feelings of inclusion or exclusion for students. For example, when academic environments glorify academic achievement, while disregarding students’ emotional and relational well-being, individuals who similarly value academic knowledge and are easily able to perform well academically may feel included in these learning environments, while those who value other forms of knowledge, such as relational and emotional knowledge, may feel excluded.

Our analyses reveal that Julian, out of all participants, values academic learning the most. Despite multiple invitations to approach his learning journey through non-academic lenses, he divides his chapters into purely academic categories (e.g., middle school, high school, and college), and his stories

remain to be concerned with academic endeavors as well as the relationships with people who impacted his academic career. The only exception is Julian's relationship with his dog, with whom he experienced a deep love and emotional connection, a "sixth sense" where he "just loved this dog and [the dog] loved [him]." While this relationship had an impact on Julian, he delegitimizes his relational and emotional experiences in the relationship as a "stretched definition of learning," and thus not applicable to his learning journey because "there wasn't a whole lot of reflecting or thinking that went on;" he emphasizes that this learning did not "influence ...anything else about [his] personality." We conclude that Julian primarily views academic knowledge as legitimate learning and knowledge, and separates his emotional and relational experiences from 'learning.' Furthermore, Julian never describes feelings of exclusion from academic realms, which we posit is related to his placement of academic knowledge as the central and most legitimate form of learning and knowledge.

Tom, in contrast, sees relationships and emotions as central to his learning journey. His most salient chapter is entitled 'Feelings and Emotions'. He also notes how important relationships are to his learning experience, describing himself as "pretty unwilling to learn in contexts that are separate from social life and social experiences" because he "see[s] ... social life being so importantly tied to the classroom." Tom notes that his emotional expression, or "all these feelings," are "all tied up in gender and sexuality" for him. When Tom realizes that he is queer, he is reluctant about his return to Celadon because of his perception of engineering as "masculine," making his emotional self and "femininity" aspects of his being "that [are] suppressed in this [engineering] environment." So for Tom, his perception of engineering as 'masculine' leads him to feel that his emotions are not welcome in the engineering environment.

While Tom sees relational and emotional knowledge as important to his overall learning journey, he also believes they can detract from his own academics at times. He notes that "I am fast to...emphasize the social interpersonal thing of how we learn in teams...and let that take precedent over the intellectual learning development that we have." Usually, he perceives the "lab partnership teammate thing" as likely to take "focus away from this intellectual development." So, even Tom, who values relationships and emotions and views them as integral to feelings of belonging, believes that they may be in tension with his academic success.

Amelia and Jessica both describe learning as something that happens in the context of their relationships. Amelia explicitly defines her view of knowledge as relational, stating that "[she] find[s] a lot of knowledge in sharing knowledge with other people." Amelia describes her high point and spiritual learning moments as "sacred" because they took place in the context of community—"it wasn't just the work [she] did—it was also the work of a lot of other people." She also notes that "it's more fun and more special to succeed when you make it happen with a bunch of other people." Amelia questions her future in engineering because she views the dominant mindset in the field as individualistic, where the belief is that "labor is

divided" and everyone thinks: "This is your lane. You should stay in it." Her perception of engineering as non-relational discourages her from pursuing engineering as a career. Amelia also describes how she feels excluded from academic spaces because of her emotions. For example, she refers to her debate coach's comment about emotions being detrimental to success, i.e., if she does not "get over [her] feelings, ...[she's] just gonna start losing, and [she's] gonna lose a lot, and everyone's gonna know it's [her] fault." Amelia adds that her emotions are not welcome in academic or workforce spaces, and consequently, she feels like she does not belong in those spaces.

Jessica also describes her experiences of collaboration as central to her academic success; for example, her high point learning moment was impactful because she and her peers "were learning to work with each other on a team." She also emphasizes emotional knowledge: a key takeaways from her story is the way she "learn[ed] social skills and... about providing emotional support for others." Thus, she positions learning as connected to relationships and emotions, and like Amelia, is uncertain how that emphasis fits into a future in engineering. We note that for both women, relational, emotional, and academic knowledge are seemingly inseparable.

IV. CONCLUSION

We find that the students in our study face experiences of belonging or exclusion based on multiple gendered factors, including their gendered identity, identity expression, and the types of knowledge they value. We find that academic knowledge is perceived as separate from relational and emotional knowledge and is more aligned with masculine identities. In contrast, relational and emotional knowledge emerge as more integrated with each other and are more aligned with feminine identities. These findings bring up important questions for engineering education practitioners who are in a prime position to create holistic learning environments with and for their students. For example, what are the best ways to embrace and embed all types of knowledge in their classrooms?

While we focus on emergent themes related to the feelings of belonging and types of knowledge, the narratives shared by our participants are rich with many additional emergent themes, such as types of "acceptable" behavior. Furthermore, we consider examining in future work students' expressions of emotion as a form of behavior, such as when Amelia and Tom cite that they believe they have to suppress their emotional and relational behaviors in order to belong. Emergent questions include: For whom is certain behavior deemed "acceptable"? How are people with marginalized identities afforded room to express "emotional" behavior?

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REFERENCES

- [1] J. M. Adler. Living into the story: Agency and coherence in a longitudinal study of narrative identity development and mental health over the course of psychotherapy. *Journal of personality and social psychology*, 102(2):367–389, 2012.
- [2] J. M. Adler. Bringing the (disabled) body to personality psychology: A case study of samantha. *Journal of Personality*, 86(5):803–824, 2017.
- [3] E. Anderson. Feminist epistemology: An interpretation and a defense. *Hypatia*, 10(3):50–84, 1995.
- [4] E. Anderson. Feminist Epistemology and Philosophy of Science. In E. N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, Spring 2020 edition, 2020.
- [5] K. Beddoes. Methodology discourses as boundary work in the construction of engineering education. *Social Studies of Science*, 44(2):293–312, 2014.
- [6] M. F. Belenky and B. Clinchy. *Women’s ways of knowing: the development of self, voice, and mind*. Basic Books, New York, 1986.
- [7] M. Borrego. Conceptual difficulties experienced by trained engineers learning educational research methods. *Journal of Engineering Education*, 96(2):91–102, 2007.
- [8] M. Borrego, E. P. Douglas, and C. T. Amelink. Quantitative, qualitative, and mixed research methods in engineering education. *Journal of Engineering Education*, 98(1):53–66, 01 2009.
- [9] M. Brucker, E. Price, D. Freeman, J. M. Goodman, and Y. V. Zastavker. Going beyond gender balance: Understanding the intersection of gender and the engineering experiences of alumni. In *2018 IEEE Frontiers in Education Conference (FIE)*, pages 1–8, 2018.
- [10] L. Butler-Kisber. *Qualitative Inquiry: Thematic, Narrative and Arts-Informed Perspectives*. SAGE Publications, 55 City Road, London, June 2010.
- [11] K. Charmaz. *Constructing Grounded Theory*. SAGE Publications, 2006.
- [12] B. C. Coley, D. R. Simmons, and S. M. Lord. Dissolving the margins: Leaning into an antiracist review process. *Journal of Engineering Education*, 110(1):8–14, 2021.
- [13] J. Corbin and A. Strauss. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. SAGE Publications, third edition, 2008.
- [14] C. E. Foor, S. E. Walden, and D. A. Trytten. ”i wish that i belonged more in this whole engineering group:” achieving individual diversity. *Journal of engineering education (Washington, D.C.)*, 96(2):103–115, 2007.
- [15] H. Gardner. *Frames of mind: the theory of multiple intelligences*. Basic Books, New York, 1983.
- [16] B. G. Glaser. The future of grounded theory. *Qualitative Health Research*, 9(6):836–845, 1999.
- [17] B. G. Glaser and A. L. Strauss. *The discovery of grounded theory: Strategies for qualitative research*. Aldine Publishing, 1967.
- [18] J. Gläser and G. Laudel. Life with and without coding: Two methods for early-stage data analysis in qualitative research aiming at causal explanations. *Forum, qualitative social research*, 14(2):75–84, 2013.
- [19] M. Koro-Ljungberg and E. P. Douglas. State of qualitative research in engineering education: Meta-analysis of jee articles, 2005-2006. *Journal of Engineering Education*, 97(2):163–175, 04 2008.
- [20] D. P. McAdams. The psychology of life stories. *Review of General Psychology*, 5(2):100–122, 2001.
- [21] D. P. McAdams. The life story interview, 2008.
- [22] M. Murphy. *Feminism, Surveys, and Toxic Details*, pages 57–80. Duke University Press, 2006.
- [23] M. Q. Patton. *Qualitative research and evaluation methods*. Thousand Oaks, Calif: Sage Publications, second edition, 1990.
- [24] C. K. Riessman. Narrative analysis. In N. Kelly, C. Horrocks, K. Milnes, B. Roberts, and D. Robinson, editors, *Narrative, Memory & Everyday Life*, pages 1–7. University of Huddersfield, Huddersfield, April 2005. Copyright for chapters remain with individual authors at all times and permission should be sought from the author for any reproduction other than for personal use.
- [25] S. L. Rodriguez, C. Lu, and M. Bartlett. Engineering identity development: A review of the higher education literature. *International journal of education in mathematics, science and technology*, 6(3):254–265, 2018.