Theorizing can contribute to marginalized students' agency in engineering persistence.

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Abstract

Within research on retention and persistence in STEM, the concept of student agency is typically treated as a personal characteristic or as an element of coping and navigational strategies. The act of theorizing about one's own experiences and persistence is under-explored as a source of taking agency. Through interviews with a woman in the first year of an undergraduate engineering major, we examine the role that theorizing about engineering culture and her own experiences plays in her constructing a narrative of persistence that counters the prominent perceived narratives marginalizing her position in engineering.

Introduction

US culture promulgates several popular narratives around engineering: engineering is hard, engineering is nerdy, engineering is masculine; engineering is either creativity in design, or an uncreative application of science[1]. Most of these narratives work against efforts to diversify engineering by attracting and retaining more students from underrepresented groups.

Research responds to and produces its own narratives, and understanding the retention and persistence of underrepresented groups within engineering is an important agenda of engineering education research. One such research-based narrative arises from a thread of quantitative research on retention, categorized by Darder[2] as "institutional research." Since these studies are primarily conducted in the interests of those with power in an institution, an institutional perspective shapes the narrative used to interpret retention data: the capable students stay, the incapable students leave, and the STEM system and institution were never at fault. More recently, however, researchers have been developing counter-narratives by focusing on student perspectives, including attention to identity and agency. For example, Seymour and Hewitt conducted seminal large-scale qualitative retention research using interviews of students at several institutions[3]. This line of research offers students a voice in helping to define the narrative for minority persistence (or lack thereof) in STEM.

Within retention-related research, the concept of student agency—and associated narratives of empowerment—has usually been connected to personal drive, social supports, and specific tangible acts such as seeking out opportunities. For instance, in a review of research on minority retention, Ong, Wright, Espinosa, and Orfield (pp. 188–189) noted "agency and personal drive" as a major resource for women of color in STEM undergraduate programs[4]. This personal quality was conceptualized not as purely individualistic but as tapping into identity in a marginalized community for empowerment. Similarly, Ko, Kachchaf, Hodari, and Ong[5] noted several coping strategies employed by women of color in STEM undergraduate Physics and Astronomy majors, including eight navigational strategies identified as significant forms of agency: "seeking an environment that enabled success, circumventing unsupportive advisors, combating isolation using peer networks, consciously demonstrating abilities to counteract doubt, finding safe spaces for their whole selves, getting out to stay in STEM, remembering their

passion for science, and engaging in activism." Note that navigating the system is also one of the three dimensions of becoming an engineer noted by Stevens et al[6].

While most of Ko et al.'s coping strategies primarily involve taking action, "remembering their passion for science" and "demonstrating abilities to counteract doubt" are primarily internal psychological acts. In this paper, we build on the insight that psychological acts can be a way of taking agency in the service of persisting in STEM, but we take this idea in a new direction. Instead of exploring psychological acts focused on oneself ("psyching oneself up"), we explore how a student took agency to author a counter-narrative of her experiences and of engineering culture by theorizing about—and critiquing—the engineering educational system and culture in which she is embedded. Our case study is an existence proof that theorizing about one's own marginalization can contribute to persistence in engineering.

Theoretical perspectives informing this study

In this study, we draw on the framework of narrative to envision forms of student agency not previously emphasized in the engineering retention literature. Ochs, Taylor, Rudolph, and Smith propose the act of narrative construction as a "theory-building activity," wherein the meaning of a phenomenon is explored and developed through story-telling[7]. In a study of dinner table conversations, they show that the meanings ascribed to events are developed or contested over the course of telling a story. Thus, we propose—and our case study illustrates—that a student may affirm or contest the meaning of their persistence in engineering via the story they tell to themselves and others.

We also draw on ideas from Critical Theory, which conceptualizes many inequitable social structures as systems of oppression that control the dominant narrative and the meanings ascribed to the actions of participants in the system[8]. In line with and extending Ochs et al's notion of narrative as theory-building, bell hooks writes about the potential power of "theory as liberatory practice" to enhance participant agency within a system of oppression[9]. For individuals experiencing marginalization there is a power in naming the oppression and theorizing about it[10]. To illustrate these ideas, we briefly consider a hypothetical female engineering student from the past, when the dominant narratives about engineering asserted or implied that students having difficulty were incapable. Using "theory as liberatory practice," the student might author a counter-narrative about her difficulties, emphasizing the subtle sexism she experiences in interactions with professors and peers. This theorizing is a form of taking agency in that the student creates a way to understand her persistence in terms of overcoming sexist barriers rather than overcoming her own lack of ability; and this internal psychological act can also empower the student toward further agency through tangible, perhaps subversive action. In this study, we saw a resonance between hooks' liberatory theorizing and the way we saw a student shape her own narrative of persistence in STEM. To be clear, neither our case study subject nor we are using formal tools of Critical Theory in this paper, but we are drawing on the notion of theorizing one's oppression.

The conception of agency in bell hooks' work and in the Critical Theory literature, including the ability to name one's oppression and reinterpret one's own experience, goes beyond the coping abilities and navigational strategies emphasized in the current STEM retention literature. While we have not found any research directly connecting this form of agency to STEM retention, we

do note that apparent acts of theorizing are common within the qualitative retention literature. Seymour and Hewitt note the prevalence of feminist themes in their interviews with women in undergraduate STEM programs; tenets of feminism seemingly helped the students understand and explain their struggles in STEM in light of broader cultural aspects of gender[3]. Likewise Jane Margolis and Alan Fisher note the presence of counter-narratives for programming amongst female undergraduate students in computer science[11]. However, in general this research does not address whether or how these acts of theorizing can contribute to individual agency and thereby persistence.

This paper investigates the role that theorizing can play in persistence within STEM fields for members of marginalized and underrepresented communities.

Methodology

Research Context

The first author conducted video-recorded interviews with four first-year female engineering students participating in a Women-in-Engineering seminar and living-and-learning program at the Major East Coast University. These students were concurrently enrolled in an Introduction to Engineering Design class, required of all engineering majors at the university. Introduction to Engineering Design was a project-based course in which students had to design and construct an autonomous hovercraft over the course of the semester, working in interdisciplinary, mixed-gender teams of 8-10 students each. Out of the four students originally interviewed, one student, "Rachel," an Asian-American chemical engineering student, organically became the subject of this study. This was due in part to her willingness to participate, as she suggested a follow up to the first interview, saying that she had further thoughts. Also, the research team reviewed interview video/transcript in group meetings and noted emerging themes of marginalization and agency. This preliminary analysis piqued our interest in pursuing these themes further. Subsequently, the first author interviewed Rachel two more times over the course of her freshman year. In the spring semester, when two of those three interviews occurred, Rachel took an English class that explored pedagogical theories in reading and tutoring experiences. This class material became pivotal for Rachel and for the content of our interviews, as it gave her tools for understanding and critiquing her own experiences with engineering pedagogy.

The data and analysis in this paper are based on the three interviews, conducted in November 2013, February 2014, and May 2014, respectively.

Narrative Inquiry Case Study

Drawing on a methodology of narrative inquiry, our study focuses on understanding, unpacking, and interpreting the narrative constructed by the focal participant, with the understanding that "human beings, individually and socially, lead storied lives"[11] and are always engaged in a personal narrativization or "telling who one is" which is central to identity[12]. The affordances of taking an in-depth narrative inquiry approach include exploring how the narrative develops and changes over time. As Stevens' et al. note, a student's present experiences can shift how they (re)describe past events[6]. We can also explore complexity in competing narratives, where multiple explanations for a phenomenon appear, and certain narratives are reinforced, refuted, or left in tension with one another. These affordances of complexity and development allow us to see student theorizing as it unfolds and to consider relative importance of narratives and counter-

narratives as they compete for prominence in the student's overall life story. In highlighting narrative complexity and development for a single student, we intend to complement large-N qualitative research such as Seymour and Hewitt which can provide patterns of agency and persistence but cannot treat individual students in great depth[3].

In interpreting Rachel's statements, we are aware that interview responses are not simply "read-outs" of the person's thoughts; rather, they arise from an interaction between interviewer and interviewee. We do not focus much on these dynamics in our analysis, for the following reasons. First, Rachel often drove the direction of conversation, going on and sustaining tangents to the direction of her original answer to a question. Second, we could not detect evidence that the interviewer's utterances triggered Rachel to change the tone and substance of her narratives. However, we cannot rule out that "interview dynamics" played a role we could not see.

Analysis Procedures

Our first step was to identify the recurring narratives in Rachel's statements—recurring stories that are not only analytically separable by us as researchers but that showed evidence of being salient and identifiable themes to Rachel herself. In order to identify narratives, we rely on linguistic markers such as use of hedges and changes in pace of talking to mark a digression, thematic repetition, or emotional response. Our first marker of narrative was structure; Rachel would often shift into a story telling mode as an explanation/illustration of a central point that she stated at the outset. In addition, her transition to story telling would often be marked by a hedging word (e.g. "well-- so") signifying a digression or aside, and finally coming back to her main point at the conclusion of the story. This aligns with a common narrative structure noted by Labov[13] (p. 13): abstract (a central point), orientation (elaboration of setting), complicating action, evaluation, resolution, and coda (restatement of central point). Our second marker of narrative is repetition; the particular narrative themes we identified came up several times during the interviews. Sometimes Rachel referred to stories already told as a shorthand reference, but often she would retell the entire story in a slightly altered form. At one point she became self-conscious of her repetitions ("You're going to be sick of hearing me talk after this") but proceeded to retell the story for the sake of continuing in her current line of thought. The third marker was indications of emotional salience for Rachel, often exhibited in a raised voice, quicker speech, and higher arousal when expressing anger, or in a lowered voice, slowed speech, and lower arousal when expressing sadness.

Having identified three central narratives, we grouped the interview content by narrative and interview date, to track how early formulations of the narratives shifted over time, particularly with respect to agency and theorizing. For short, we have named the three narratives which are examined in this paper: "I suck at math," Women in STEM, and Nature of Engineering. Although we present the narratives separately, we (and evidence suggests, Rachel) see the narratives as intertwined rather than isolated and as central components of the overall narrative that Rachel is communicating. Within each of these three narratives, we identify substructures to her stories: one or more culturally-dominant narratives which have been perceived and received by Rachel from some source—a popular idea present in society, in a family/parental conversation or interaction, in an interaction with a person with institutional power—all of which have the effect of marginalizing Rachel; this is intertwined with counter-narratives constructed by Rachel, which we propose represent acts of theorizing as liberatory practice.

Within each of Rachel's stories, the narrative elements which we are mapping to culturally-dominant are richer than simply a regurgitation of a popular cultural meme such as "girls are worse than boys at math," and include experiences, emotions, and circumstances unique to Rachel's life. Likewise we do not suggest that the culturally-dominant narrative represents the whole of how Rachel experiences it in her interactions with individuals and institutions. Instead, we have tried to capture the rich tapestry of Rachel's experiences as best as we can given the limitations of length and of the paper medium. We also do not see a wide divide in how Rachel experiences the culturally-dominant narrative in her interactions with others and the counter-explanations she constructs to find her own agency; these, we feel, are strongly intertwined for Rachel, embodying both vulnerability and strength, threats and opportunities as she experiences them. The reason we divide our story-telling of Rachel in this manner is for ease of presenting the argument and analysis.

Data and Analysis

In narrative analysis, the usual researcher practice of presenting all the digested data and only then discussing/interpreting it produces impossible-to-follow arguments. Therefore, in each of the three subsections below, corresponding to the three identified narratives, we interpret and discuss the data as we are presenting it.

"I Suck at Math" Narrative

A prominent theme in Rachel's interviews is her low math self-efficacy, sometimes coupled with a low opinion of her "technical" (coding, circuit-bulidng, etc.) abilities more generally, and sometimes contrasted with higher science-specific self-efficacy. Some form of the "I suck at math" theme came up in all 3 interviews, usually with very similar wording, usually to help explain one of Rachel's actions. One form of this narrative comes with a 2nd person wording, as a familial narrative, as illustrated by this quote from our 1st interview:

> And then when my dad asked me like why would you do that [apply to UMD Engineering program] you suck at math like why would you apply. Why would you apply to-- Because I was out of state for MD and there was a little bit of concern that I wouldn't get in just because of SAT scores and, my SAT scores, they weren't bad it's just I got a 670 but it wasn't like 700 range. And so my dad was like your math, your math grade wasn't very good, you didn't take calculus…

At other moments Rachel expresses this same theme as an internalized first person narrative, "I have to admit that sometimes when I'm like I can't believe I suck at math, like why?" (1st interview), "I guess career-wise maybe so I'm not very strong at math" (2nd interview), and the following passage from the 3rd interview:

> I realized, like, one: I sucked at (ooh… gosh...). Um, you're probably gonna be sick of hearing me talk after this!...
> S: No no...
> R: 1- I suck at math.
> S: Ok...
> R: I don't suck, I was, was pretty weak at math. I didn't have natural. My sister has a lot more aptitude for learning math.

The repetition of this theme, in both 1st and 2nd person speech, suggests that this is a prominent internalized and shared familial narrative for Rachel's STEM experiences. The somewhat agitated affect and precision of the 1st interview quote suggests that Rachel remembers her father as having said this precise thing or similar, and the repetition across interviews shows its stickiness and influence in Rachel's thinking. As a familial narrative, this narrative pushed Rachel to limit her choices; her father questions why she would "even apply" to UMD and/or an engineering major generally, given her weakness in math. Furthermore, the "I suck at math" narrative coincides with a broader popular narrative about engineering as being heavily mathematical and engineers as needing to be good at math (National Academies Press, 2008). Its alignment with this dominant narrative may give "I suck at math" part of its emotional weight, and makes it dangerous to admit.

On the other hand, Rachel's parents are also influence her to choose STEM fields: Rachel feels she must choose STEM as the only "academically credible" option regardless of what is "fun" and enjoyable for her (interview 3). Thus, in this familial narrative we see both a narrative marginalization (in telling Rachel she isn't suited for engineering) and a restriction of Rachel's agency (in pressuring her to major in a STEM field other than engineering). In the context of her family's views and internalized self-efficacy about her mathematical and technical abilities, Rachel's application to engineering and her framing of it as going against her family's wishes and her own fears can be seen as resistance to an otherwise oppressive narrative that limits her agency. Here our 1st interview picks up after the quote from above where her dad questions her application to the engineering major:

> …and then I got in as a chemE major and I still sometimes wonder well I guess they must have seen something, because I know my essays were really good. My past wasn't that good but somehow I was like ok I really really want to do this and I really liked taking physics in high school. So um...
> 1st interview

Here we see Rachel forming her own counter-narrative invoking her own cultural capital (resources valued by STEM culture, in this case her strong writing skills) and her reasons for persisting in STEM, namely strong intrinsic interest. Her affect here is fairly cautious and more subdued than usual; perhaps she is tentative or slightly embarrassed to be building a positive story for herself and resisting her parents' story. While it's not true that this counter-narrative simply replaces the deeply internalized "I suck at math" narrative—we see the "I suck at math" narrative return in subsequent interviews—it is noteworthy that in the localized logical flow during the first interview, Rachel's own narrative disrupts her parents' story for her presence and persistence in the engineering major. Rachel's agency in this case involves both real world action, applying to the engineering major against father's advice, and resisting the dominant narrative that success in engineering is impossible without being good at math. .

The other prominent way we see Rachel counter the "suck at math" narrative is through cultural and circumstantial explanation. Instead of seeing math performance as a reflection of her inherent ability, Rachel tells a story of how her high school preparation and experience contributed to her being inadequately prepared in math. This includes early instructional

deficiencies ("going back to middle school I had really weak algebra training"), structural disadvantages (at her private all-girls' school in Connecticut, even good students rarely took calculus), and cultural/familial particularities (asking to take a summer math class but always needing to visit family in Indonesia instead). Although her math self-efficacy intersects with her worries that the common belief about boys being innately better than girls at math may come true, she resists this form of stereotype threat with a logical counter-argument:

> I have to admit that sometimes when I'm like I can't believe I suck at math, like why. And I know it's not because I'm a girl it's because I never had that proper preparation starting from my freshman year of algebra to not taking calculus.
> 1st interview

For Rachel, a cultural explanation of gender differences appears more empowering than a biological gendered explanation; if sucking at math is biological then there is nothing she can do, but if it is based on prior schooling she can work hard to fix it. Her explanation of her deficiencies resonates with scholarship that a growth view of intelligence is more productive than a fixed view[14]. Envisioning Rachel's narratives and counter-narratives as coexisting and competing for explanation within her everyday thoughts and story-telling, we see the "I suck at math" narrative of internalized low self-efficacy and gendered biological differences is not completely replaced by the new counter-narrative in a static way. These remain points of insecurity for Rachel, as we might expect. But the localized logical refutation shows what may be an internal conversation Rachel has with herself, which has been rehearsed and reinforced over time due to its productive empowerment.

A final way Rachel resists the "suck at math" narrative is through active work to counter a culturally dominant belief about the importance of math in engineering. Rachel develops a sense of a bigger "real world" out there that rarely gets represented in her STEM classes, a sense that engineering jobs rely more on soft skills and cultural understandings and less on math. We see agency through what bell hooks style "liberatory theorizing" simply in the production of that counter-narrative; but remarkably, Rachel actively seeks evidence in the "real world" to confirm her theorizing. She attended networking events (set up by her Women in Engineering program) to make contact with real world engineers. At these events, she asked several professional engineer alumni "What was the most useful class you ever took?," a common answer was Engineering Leadership) and the importance of Calculus and math calculation skills on the job. She particularly wanted to clarify the importance of Calculus, after she received a disappointing "B" in her first semester. The engineers' answers reinforce her sense that real-world engineering has a place, and a prominent place, for Rachel:

> And he's like, let me tell you-- on a really bad day I have to square something. Like I have to like make the cosine of Pi/3. And I was like oh really? He's like yeah… like… I don't, like, and he was saying like, you can always be an analyst engineer, like punch numbers, crunch them. But they keep you in the basement. If you actually want to be someone who does things that they put on brochures. You have to be able to know all of this [gestures towards humanities side on concept map she made]. And I could tell all those people I talked to, those these successful alumni who clearly were in positions of great like-- they they had this [humanities side]. They had you know all of this stuff.
> 3rd interview

Here again we see a powerful mix of counter-narrative production and direct action in support of Rachel's taking agency. The counter-narrative that she might struggle with math now but one day she'll be the one on the brochures competes with the narrative that she will struggle with math forever and eventually succumb to the fact that she cannot survive in engineering. And beyond that, Rachel is actively (and seemingly accurately) seeking input from a particular slice of the real world in supporting this counter-narrative. In this way Rachel's networking and narrative construction could all be viewed as navigational cultural capital[6,10], as well as liberatory theorizing. She is working hard to combat familial, societal, and personal marginalizing narratives of math inability, and to find her own empowering meaning in persisting in engineering anyway.

Women in STEM Narrative

Another prominent and marginalizing narrative for Rachel connects to a cultural narrative of women as a minority in STEM fields: Rachel tells a story of herself as "fighting the statistics," fighting sometimes intangible forces, in her attempts to persist in engineering. There is a feedback relationship between cultural narratives, women's self-perception, women's outcomes in STEM, and research / media reporting, and we can see Rachel's self-perception in the context of this milieu.

The clearest marker of this narrative is in Rachel's knowledge and repeated mention of representation and retention "statistics," for example: "And I don't know why the statistics like work out that way." This quote, embedded in an explanation for why women choose lower-prestige roles on their design teams in the Introduction to Engineering Design class, has lowered affect, suggesting sadness, resignation, a certain feeling of being stuck. The "I don't know" also seems to represent a moment of confusion, of not yet having come up with a satisfactory explanation for why women are a minority in STEM. Although retention statistics clearly contribute to this narrative, Rachel also folds into this narrative her experiences with other women in STEM, from her all-girls' school and the university Women in Engineering program seminar she attends (and from which we recruited her):

> Um, again maybe because again going to an all girls school for 4 years of my life we were always told just do what you want and you shouldn't like blah blah blah bullshit, everyone will tell you what to do, blah blah, because you're a girl, blah blah, and you can *buck the statistics* blah blah blah.
> 1st interview, (emphasis ours)

The dominant statistical narrative from these popular and institutional sources is coupled tightly with certain actions required of girls in order to succeed:

> So to me the fact that like um I don't know I guess sometimes throughout-- yeah I went to an all girl's school so I've been hearing this for like 4 years of my life. 'You guys should definitely be more technical be improve your math skills and blah blah blah'
> 1st interview

> and in our [Women in Engineering] seminar they'd be like 'Oh girls don't let them be like only do the organizational stuff'
> 1st interview, (with respect to ENES 100 project team roles)

In the above quotes, “blah blah” is a marker of having heard the same well-known narrative many times and having grown tired and/or reacted negatively to it in the first place. We note the following markers of a lack of agency in Rachel’s rephrasing of the narratives given to her: “oh girls” (likely patronizing), “don’t let them” (imperatives on her actions rather than leaving the choice of action up to her), “everyone will tell you what to do” (framing impending gendered actions with a removal of agency), and “we were always told” (blanket advice regardless of circumstance). There is an underlying message to these narratives that because Rachel is a woman she should feel compelled to “buck statistics” and resist being relegated to “girl” roles. With respect to this topic, Rachel may also be conveying a sense of being talked at, rather than with.

Rachel resists and works to deconstruct this dominant popular and institutional narrative for women in engineering via multiple counter-arguments and explanations. At one point, she has a strong affective reaction to retention statistics and connects them to the “suck at math” narrative:

> I said it and I'll say it again, like I don’t want to let the system down. I have to admit that sometimes when I'm like I can't believe I suck at math, like why. And I know it's not because I'm a girl it's because I never had that proper preparation starting from my freshman year of algebra to not taking calculus. It just so happens that I'm a girl! *And I'm like f*** this*-- why does it just happen to be that way?
> Interview 1, (emphasis hers/ours)

Through the development of the counter-narrative—that she is a girl who happens to be behind in math as opposed to someone who is bad at math because she’s a girl— Rachel builds into a heightened and angry affect, showing resistance through emotion. As for the advice of the Women in Engineering program regarding team roles, she finds it “ridiculous” and “completely unfair that the girls are expected to be a guy in engineering,” with a sense of exasperation at the program coordinator’s lack of acknowledgement of the hypocritically stacked playing field (i.e. women are powerful! but actually be a guy). She continues this deconstruction of the idea of stereotypically feminine team roles further, pointing out the hypocrisy of blaming girls for doing what they are good at:

> If because you are a girl and just happen to be really good at organizing or planning or doing numbers or making nice spreadsheets, that should *not* be an indication that you are failing.
> 1st interview, (emphasis hers)

> If she's good at paperwork, *paperwork*! I mean again, no one wants to do it, yet why do people go to business school to become accountants? It's because it's important.
> 1st interview, (emphasis hers)

In this counter-narrative, Rachel builds toward an implied message: Don’t ask girls to change to be more valued by the Engineering system; ask the Engineering system to change to (re)value all students in more accurate and gender neutral ways. Rather than viewing team roles as inherently restrictive and gender enforcing, she provides an alternative framing for her stereotypically feminine strengths, skills, and weaknesses: “I am a girl and I am different from a guy in engineering and that is good. I think I help my team by being different.” Over the first interview

we saw many examples of Rachel describing her big picture insight, visualization, strategic thinking, oral and written communication, management, and delegation, skills that she feels are not high-status. For example "a lot of the boys in my group are very technical but whether or not they feel comfortable taking on my [management] role…" (i.e. she knows a lot of the boys could not comfortably take on her role, one teammate has told her this explicitly). Here again we see Rachel acquiring agency by raising questions and sometimes taking action to resist both the dominant narrative about "real" engineering as centered around stereotypically male roles and the standard coping strategies suggested by her Women in Engineering program ("don't get pushed out of those real engineering roles!"): She recasts her "soft-skills" role on her design team as important, hard to fill, and something she actively chose rather than is getting relegated to.

As another component of her narrative for Women in Engineering, Rachel brings up a piece of advice from a Women-in-Engineering seminar in the 3rd interview:

> There would be some effect on like my frivolity in terms of like my ability to do it like for example like for our like [Women-in-Engineering] seminar thing um, you know she'd be like-- you can definitely go with pants, like if it's wear a dress make sure it's not like too bright and too colorful for interview you know you want to look like, you know. (3rd interview)

This advice from the Women-in-Engineering seminar and outside sources correspond to "coping strategies" to make the women's lives easier in male-dominated STEM departments[5]. Rachel and her peers resist the Women in Engineering seminar's fashion advice by examining the assumption that feminine norms of dressing should adapt to masculine norms (continuing on from prior quote):

> And all of the other girls in my class were like, but if it's cute it's cute! Like, you know, if it's still professional it's professional, like if it's like you know a plain dress but it's like bright orange. I think that's acceptable you know and most women now would opt for like the pant suit and blazer just so they can get past like that stereotype or conception so it's not just like aesthetics I think there are other things that are undeniably female that are completely ok and fine, that sometimes misses the mark and again like… I think my two students like A--- and J--- I think they might be too female for some people's definitions to ever consider STEM. Cause they're too loud and too passionate and um… they care about things that are considered frivolous and to the majority of people in this field they're you know logical practical pragmatic, traditional.
> 3rd interview

To another set of ears the Women-in-Engineering suggestions might seem well-intentioned and at most mildly restrictive. And yet, to Rachel, this advice arouses a passionate response, indicating the extent to which the advice feels excessively restrictive, denying her the agency to interpret and decide her best course of action. Inden's definition of agency may be helpful[15]: Women-in-Engineering in some moments treats Rachel like a helpless *patient* and like an *instrument* of their own feminist initiatives, rather than empowering her to come to her own interpretation and appropriate response as an *agent*, or to take up the feminist cause via her own logic. Although such advice is clearly well-intentioned and has undoubtedly proven helpful to

many women, it seems assimilationist and oppressive to Rachel when she is engaged in liberatory theorizing about how engineering culture can and should adjust to gender diversity.

We note here that Rachel casts her stereotypically feminine strengths and preferences as an assertion of her femininity (e.g., "I am a girl and I am different from a guy in engineering and...I help my team by being different") while also resisting the view that her stereotypically feminine weaknesses such as math skills are connected to her gender (e.g., "I know it's not because I'm a girl it's because I never had that proper preparation...It just so happens that I'm a girl!"). In this way, Rachel's "suck at math" and Women in STEM narratives both draw on and resist gender essentialism, the idea that men and women are essentially and inherently different. This selective acceptance and rejection of elements of familiar cultural narratives is, we speculate, a common part of "liberatory theorizing" as a way of taking agency. In light of this selective uptake of gender essentialism, it is not surprising that the culture of engineering at her institutional culture feels oppressive to Rachel, in failing to value her stereotypically feminine "soft skills" and performance , whereas she does *not* see as oppressive the broader cultural norms about how women should dress ("if it's cute, it's cute") and perform (emphasizing "soft skills").

Still, many questions remain unanswered about why Rachel sees the Women-in-Engineering advice as oppressive rather than a helpful coping strategy. Are the Women-in-Engineering leaders enacting a "2nd generation feminism" formed under shared experiences of women surviving in the workplace in the 80s and 90s, whereas Rachel's millennial peers do not have an appreciation of where these strategies and interpretations came from, and feel coerced? Alternatively, are teacher student-power relations at work? Did classroom norms prevent Rachel and her friends from raising these objections during the seminar, or did they only come to these conclusions together after class in the dorm? Whatever the answers to these questions, we see an increase in personal agency for Rachel in reframing her teamwork and fashion choices as a form of resistance; Rachel decides she has good judgment and can make up her own mind rather than just follow Women-in-Engineering's rules. In another interesting intersection between rethinking things and taking real-world action, Rachel dresses subversively on several noted occasions (e.g. people say she dresses "like an art major") and (half-jokingly) suggests that she stays in engineering partly to "help people dress better along the way" (3rd interview).

In summary, within the Women in STEM narrative, Rachel resists and reinterprets several cultural narratives and particular experiences from society at large, her engineering department, her Women in Engineering seminar, and her all-girls high school. The counter-narratives she forms around Women in STEM deconstruct the dominant norms for skills, demeanor, and dress, a kind of liberatory theorizing that increases her agency in choosing to subvert those norms in personally authentic ways.

Nature of Engineering Narrative

As a student in her first year of college, Rachel is in transition between the high school and university worlds. Within such a destabilized landscape, students are likely to seek to understand the new cultural context and transition into newly formed identities. For engineering students, especially those from marginalized groups, there may be an especially urgent need to define engineering and themselves as engineers. (Seymour and Hewitt[3] and Margolis and Fisher[11] have noted this sort of additional identity work required of marginalized non-dominant groups entering undergraduate STEM and computer science majors respectively). Within this

intellectually and emotionally charged transition period, messages sent by course content, textbooks, professors, and peers about what constitutes engineering might be particularly important. For this reason, we were not surprised that Rachel was strongly attuned to the messages she was receiving about what counts as engineering, and engineers. In short, the dominant institutional narrative Rachel perceives about engineering is that it is monolithic, heavily technical, and uncreative, a narrative which coincides with a broader cultural narrative[1]. She expresses frustration with several elements of her first semester: the pace of lecture, lack of real-world application, and lack of meaning. For instance, when asked what she learned about design from Introduction to Engineering Design, she replies:

> R: Nothing.
> S: Ok
> R: Um, I learned more designing things probably playing with Legos and play dough when I was a kid.
> …
> It's that you're following the textbook steps on how to build it, But in fact what you're really, I think the whole what I learned was trial and error and planning.
> S: Mmhmm
> R: Not design. Design to me involves innovation and concept and there's supposed to be a message across like you're supposed to design something for purpose.

Implicitly, the class (a group project to design a robotic hovercraft) has attempted to teach her its conception of design, and she is already resisting the class's definition, calling what the class does "trial and error and planning" rather than design—a fairly subversive act considering her lack of formal training in engineering and design. And yet, she does have an intuition for what the word means to her, and refuses to relinquish the meaning to the course structure. Likewise when speaking more broadly about engineering:

> S: What is it like having that be your first semester in engineering, make you think about engineering. Like has it--
> R: Typical.
> S: What do you mean?
> R: Like what everybody says it is. Just power through and not fail and get your degree. Um, it wasn't like a surprise to me that it was kind of like that. I was excited for the class. But what I saw that really what I was spending my time on was just trial and error and making things work. If we had time to like pull apart the fan and be like oh look there's the gear that actually makes the Q run. Or like there's the point that like sends the signal, um. I don't. It doesn't give me any negative connotation on engineering whatsoever.
> S: You just don't think that this represents
> R: Engineering
> S: (Laughs)
>
> R: No. No.
> S: You just think
> R: To me it's just kind of one of those classes like everyone was saying you just have to take it. And we all hate it we all just.

The lack of inspiring engineering content fit into a common narrative she had received—generated and propagated by engineering *student* culture— that a "typical" engineering major's path means "power through and not fail and get your degree." She resists allowing the class to create (or allowing the interviewer to infer?) a negative connotation with engineering in general, because she rejects her "engineering" experience in the class as the only definition of engineering. This is the picture we get in the first interview. It is not a fully fleshed-out counter-narrative for the nature of engineering, but it hints at a willingness to resist having "engineering" defined by others in ways she does not like and that marginalize her.

At other points in the first interview, however, her courses' emphasis on technical content, which contrasts with her own skills in communication, teamwork, and strategic planning, causes her to question her position in Engineering:

> I do doubt like am I really fit for engineering? Like what am I supposed to do with like all this art and science, like all this English and science stuff and English literature stuff? Like so far I can definitely manage the team, I know what's going on, I can talk to the instructor, I communicate really well. I can build the hovercraft if you tell me what to do. But if you ask me to design the circuit schematic I wouldn't be able to…

The dominant institutional (and broader cultural) narrative about engineering, that it centers around technical skills such as designing circuits, is therefore marginalizing and disconcerting to Rachel. If her experiences in Introduction to Engineering Design represented what engineering is really like, Rachel's position and future in engineering would come into question.

As mentioned previously, in the spring term, Rachel enrolls in an English class with a focus on pedagogical theory and a service learning component where she tutors/mentors students at a local high school. Possibly by instructor design, Rachel is mentoring racial minority female students who have interests in STEM careers, causing Rachel to reflect heavily on her own development and experiences. The second interview with Rachel is centered around concepts and experiences in her English class. Rachel appeared to be feeling excited and empowered by the new educational theories and eager to map them onto her engineering experiences. This may be why she requested a second interview; she seems to have wanted to connect these ideas to the prior conversation and to make sense of a lot of synergistic ideas around the same topics.

Among other new concepts and theories, Rachel uses the central concept of *plurality* to help map out and sharpen her new proposed critique of engineering (and STEM). Plurality means many interconnected things for Rachel, including diversity of perspectives and backgrounds, interdisciplinary work, and taking into account multiple dimensions of design problems or engineering work. Considering engineering curriculum, Rachel (as she did with "demoting" Calculus) draws on role models and contacts from the "real world" of engineering/business to support her arguments, this time for plurality as important in engineering. From Rachel's perspective: in the real world, everything is interdisciplinary and intertwined, and cultural nuances are important; while in the engineering classroom all of that is excluded. She sees her role models (Bill Gates, Steve Jobs, Jack Welch) as the exception, not as having learned plurality from their engineering courses/degrees:

> But that's again this is very few people who out of their own volition will encourage that and therefore. If society doesn't encourage that the departments won't ever encourage that. Because academia is a part of society. And therefore the professors, the professors I think have plurality themselves but they see that: Oh these kids are going to go into technical jobs they're going to work for Boeing or design some cool stuff. They're never going to have to worry about what the product actually does, they're never going to have to worry about ok like who's actually making the metal. Where is it coming from?
> …
> But the fact that like the cultural demand or the societal demand on engineering school is producing these really genius people who are just technically brilliant. Doesn't ever-- they don't ever need to change or adapt the department.

Rachel connects academic engineering culture to broader culture. By her account, professors may have a conception of plurality themselves but do not value passing it along to their students because the culturally expected role of engineers is not to worry about complex, interdisciplinary, plural elements of their designs. Rachel extends this argument in the 3rd interview, viewing her university as responding to social forces for the preparation of "boring process engineers," whereas elite universities are creating CEOs, game-changers. By continuing to develop critical cultural deconstructions of the university's engineering department, she seems to be reducing its power over her.

Her theorizing about the staunchly non-plural academic engineering culture in which she is immersed does not seem to constrict or depress Rachel; rather she uses the construct of plurality to help give extra meaning and value to her own background and skills. So, for her, the theorizing is liberatory, not marginalizing. For example, in this quote, Rachel talks herself through her frustrations with her technical preparation by reversing the traditional narrative of the importance of technical versus "pluralistic" content.

> And then now I'm in the engineering school and I'm like why, and I could the thing is when I thought about this more I was like-- maybe I'm just being really really stupid and I'm just considering plurality is like this really bad idea and I'm just being super biased because I learned in high school. And I'm like I should have come in with more technical skills-- cause the first I think half like the last half of my semester when I was on winter break I was really angry that I just didn't come in with the technical preparation that everyone else did. I was so angry I was really mad I was like oh man and you know I just need to put I just-- who cares about all this other stuff it's all pointless I can't believe I cared about English and whatever it was.
> …
> So, when I thought about it more and I was like I could always improve my technical skills I could always get better grades in my technical classes because I have to study. On the other hand you can't always develop your sense of cultural plurality or your sense of your transfer studies or your ability to model and connect relationship between your technical skills and your application.

In this noteworthy narrative reframing, it makes sense for Rachel (lacking in technical skills but high in plurality) to persist in Engineering, whereas it sounds like those with strong technical skills would be better served taking more English courses.

In general, when discussing the nature of engineering, Rachel's narrative a shifts from the first interview to the second. In interview 1, Rachel is resistant and frustrated with the way engineering is being presented, but her critiques focus mostly on specific classroom practices and her struggles cause her to question her engineering trajectory. In the second interview she moves to a much more actively critical position, where she connects many of her prior complaints to newfound pedagogical theories and impressions of the real-world value of plurality in all its senses. This is a good example of bell hooks' liberatory theorizing at work, empowering members of marginalized groups in the process of making meaning of their oppression. We see agency both in how she theorizes about her educational environment and in the options opened up to her by her revised vision of the nature of engineering and her place within it.

Implications and Contributions

Our analysis of Rachel's narrative construction follows the development of one subject's narrative along three prominent themes, and analyzes them over time in order to track the parallel development of critique and personal agency. Within each of the main themes of "I suck at math," Women in STEM, and Nature of Engineering we see Rachel has perceived a culturally-dominant narrative that tends to marginalize her in the engineering field, and we see Rachel construct one or more counter-narratives which increase her agency in various ways.

We propose that this study has contributed the following primary implications.

Agency as Theorizing Student Persistence

Agency of marginalized groups within STEM departments has primarily been conceptualized as coping mechanisms and navigational strategies, whereas the concept of agency through critical theorizing and the reshaping of one's own narrative is relatively novel. In this study, Rachel rejects the coping strategies presented to her with the aim of helping her persist as a woman in engineering. She perceives these strategies as pushing her to find agency by being more like a male engineer rather than valuing her own strengths. Instead she argues in support of her natural skills of organization, management, and writing as being central to engineering practice and wants them to be recognized as such. Rachel finds agency in creating a narrative that challenges perspectives that tend to maintain the status quo of technical knowledge and male-ness in engineering culture. We are not suggesting that Rachel's arguments should form a new blueprint of coping strategies to present to other students; other students will likely find agency in other kinds of narratives that speak to their experiences. The point is that those concerned with student persistence need to attend to and value the components of agency that are salient to individual students, including those which are rooted in students' theorizing about their experiences. This work may help us understand processes of student persistence better.

Case Study of a Student Narrative

This case study provides an in-depth examination of students' narratives about their persistence in STEM, in ways which are rarely explored in the STEM retention literature and which complement that literature with nuance and complexity. A single case study prevents us from drawing conclusions about patterns of theorizing by students, from suggesting narratives that are more or less salient to students, or from providing recommendations for particular narratives that might help students cope with marginalization within the engineering culture. However, in this study we have shown as proof of concept that a process of theorizing can occur and that, at least

in this case, it appears important for the student's persistence. Although we think Rachel is somewhat unique in her depth of critical insight and openness to sharing, we posit that further investigation in this line of research is likely to show that the process of theorizing one's persistence in engineering is not limited to outlier students. Based on this intuition and the case study, what we can draw as implication is the need - for educators, student advisors, and education researchers - to attend to the theorizing students do as they try to navigate and persist within engineering programs.

Instructors Could Encourage Student Theorizing

Finally, we note a tentative practical implication. Narrative construction appears to be a source of agency for Rachel and a potential resource for her persistence in engineering. On the basis of this exploratory study, we propose that faculty and student advisors, who have a vested interest in student retention, should pay attention to and support processes of theorizing by students.

At this point we can only conjecture what sort of instruction or support this would look like, and ask questions that might be answered by further study. Rachel found substantial support in her narrative construction not from within her department but from outside, in a pedagogically-based English class. We wonder if this kind of theorizing can even be taught by those in power in STEM, when some of the culturally-dominant and marginalizing narratives are (through action or inaction) bolstered by department cultures. Rachel actively seeks out experiences like our 2nd interview and the English class as opportunities for theorizing. Would other students find the process of simultaneously deconstructing the very curriculum they are being taught too disconcerting? Rachel is only in her second year at the time of writing, and we intend to extend this study longitudinally as she progresses. Although she appears to be strengthened in her resolve to persist through an awareness of her own marginalization, other research suggests that this awareness and comfort with that awareness is different for different students[17,18]. Is there a chance that critical theorizing, for Rachel or for other students, actually leads to increased student attrition in cases where a new awareness (of the "real world," of engineering culture, of the department culture and curriculum) makes participation more difficult? While we take these potential drawbacks seriously, we look towards the potential impact of encouraging student theorizing as worth the additional effort of the research and practitioner community to investigate its limitations and nuanced applications further.

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