Burning Bridges: Considerations from a Structure-agency Perspective for Developing Inclusive Precollege Engineering Programming

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Burning bridges: Considerations from a structure-agency perspective for developing inclusive pre-college engineering programming (Work-in-progress)

The conversation around youth engineering work has increased in volume over the past decade. As college engineering programs struggle to attract and retain individuals who identify as BIPOC, women, LGBTQ+, and/or from disenfranchised socioeconomic groups [1], outreach efforts to attract youth from diverse backgrounds to the field have increased. Further, the advent of the Next Generation Science Standards [2] has positioned engineering experience as a means to broaden participation in STEM writ large and has brought pre-college engineering more explicitly to the national consciousness [3]. Prior research has sought to explain why youth from historically marginalized backgrounds might veer away from engineering before college. Some proposed explanatory frames, such as the "leaky engineering pipeline," suggest skill or experience deficits may prevent historically marginalized young people from pursuing engineering [4], [5]. Other scholarship explores early interest and identity construction in engineering, calling for greater engagement in quality engineering programming [6], [7]. Although distinct in their reasoning for continued diversity concerns, each model calls for increased efforts to engage all young people in engineering. As engineering continues to be framed as the profession of choice in the contemporary world [8], supporting youth in the disciplinary work of engineering and actively addressing continued exclusion within the field are crucial areas of study.

To improve access to and experience in engineering, engineering educators need to develop experiences that do not replicate past exclusionary practices or perpetuate injustices [9], [10]. We need to sustain and support the diversity of learners' cultural experiences and interests, thus necessitating close study of youth from cultural backgrounds and experiences not typically privileged in engineering and potentially rearranging how we "do" engineering altogether [11]. In this paper, I discuss how structure-agency perspectives [12], [13] might be useful to this work in pre-college engineering. Borrowing from science education literature, interrogating how structures and agency are operating within a space help, "shift the analytic frame…from focusing on youth as in need of remediation to rethinking new arrangements, tools, and forms of assistance and participation in support of youth learning science" or engineering [14]. In this sense, using this framing might open different perspectives as we continue to design engineering experiences for youth. To explore this point, I provide data from the story of one youth, Mariabella, who worked with me in a community engineering program. I overlay an example structure-agency analysis on this data. The purpose of this paper is not to empirically present results or to generalize, but to showcase patterns of Mariabella's experience through a structure-agency perspective. Further, I offer this perspective as part of an ongoing conversation on how the field might study engineering engagement and guide the development of future programs.

Conceptual Frame

Previous research directions examining youth engineering work often focused on if and how youth have access to pre-college engineering experiences [15]. Less work has looked at how youth understand and make meaning of these experiences designed to attract them to the field. Instead of broadly asking if youth "have" learned engineering, I suggest that the field should

focus on how, why, when, and if youth see themselves within engineering design work. To support this effort, I leveraged sociocultural-historical theories of learning to emphasize the dynamic interconnection between learning and personal knowledges, commitments, and identities, as well as the relationship between individuals and disciplinary communities [11] I take "engineering" to be a socially constructed cultural context built on historical norms, practices, and social decisions that youth are experiencing and making sense of [16], [17]. Given continued diversity concerns in engineering, it is important to explore pre-college engineering learning in ways that attend to the role of identities and cultural practice in doing engineering work [17], [18] and to human-centered understandings of engineering that frame, delimit, and try to solve real-world problems connected to young peoples' lives. Without attending to these ideas, supporting youth engineering might reproduce the same systems of inequity and exclusion seen in post-secondary settings.

Within a sociocultural frame, I focus on the idea that "as they participate in joint activity, people simultaneously exercise agency and are constrained" [19], or what one might label a "structure-agency dialectic" [14]. The structure-agency dialectic concerns the negotiation of individuals to resist, maintain, or further interact with larger structures that could be material, social, cultural, cognitive, or organizational [14], [20], [21]. Structures can be viewed as "…always both enabling and constraining, inherent in virtue of the inherent relationship between structure and agency (and agency and power)" [20]. In an engineering experience for youth, structures could be the curriculum itself, the social organization of the space, or "the rules and regulations of everyday life" that constitute what engineering is [21]. Depending on the situation, these structures likely harken from the historically white, male, classed engineering culture. Presupposed knowledges, activities, and practices within this dominant culture could be considered structures [22]–[24]. Agency can be "thought of as the *strategic* making and remaking of selves…" [25]. As such, youth can construct and exercise their agency amidst structures in a variety of ways.

Considering this lens is important to thinking about pre-college engineering because "…what people believe they can do and the actions they take depends, in part, on, and influences, who they think they are and who they want to become" [13]. In this sense, looking at questions of access and inclusion through structure-agency perspectives reveals a more holistic picture about what is "at play" in any given moment [22]. This framing also helps interrogate how youth are positioned in outreach programs and how they respond to that positioning, thus countering perspectives that locate a deficit with youth themselves [13], [17], [26]. These frames help make sense of roles available to non-dominant youth in engineering activity and frame their engagement.

Methods

Drawing on calls for small "n" qualitative work [27], [28], this paper uses data from the experiences of Mariabella, a 16-year-old Latina youth from a large Midwestern city on the rebound of economic decline. She is one of seven focal youth from underrepresented backgrounds that I worked with over two years as they engaged in engineering work through an out-of-school community engineering program. Designed by a team containing the author, the program engages youth in defining a community engineering problem of interest, researching

that problem, and developing a solution. I led the programming multiple times over three years within an afterschool and summer context. 75% of sessions were video-recorded, resulting in at least ten hours of clearly visible video per youth. I interviewed youth via focus groups at the end of each project and collected all youth-produced artifacts. To conclude data collection, I conducted reflective, stimulated-recall interviews with each youth. Per qualitative best practices, I member-checked claims with focal youth.

For this paper, I selected pieces of Mariabella's data as analytical examples from the larger data set. Mariabella emerged as a particularly interesting focal youth due to her general disinterest in engineering but repeated participation in the community engineering program. In the larger study, I undertook this process of moving iteratively from data points to holistic claims and back again repeatedly, using key linkage charts, category charting, and theoretical memo writing to map an evidence trail throughout the process [29], [30]. I drew upon theoretical coding that analyzed the interplay of structures and agency, as well as theoretical memoing, to present the following discussion.

Emerging Findings

Using a structure-agency perspective, I present moments of Mariabella's story. Particularly, I examine two examples of Mariabella's agency and how the structure-agency dialectic is implicated in her experience. Looking at these moments, I aim to shift the analytic frame from Mariabella's disinterest in engineering to what might be implicated in her disinterest. These examples are not meant to be positioned in opposition to one another, nor are they meant to be representative of all youth studied. Rather, they provide insights into how research from this lens might inform inclusive engineering environments for youth.

Meeting Mariabella

On the first day I met Mariabella in the community engineering program, she shared with me how she disliked engineering. On a community walk, she told me about a time in her middle school STEM class where she had to build a marshmallow launcher. "Why would I want to do that?" she rhetorically asked (Field Notes, 07/17/2018). At first glance, Mariabella appeared to be disinterested in engineering. On her second day working with the community engineering program, she offered, "I love people, but I hate technology" (Video Transcript, 07/18/2018). Yet, Mariabella participated in the community engineering program for two years, defining and designing toward community problems. Over time, we reflected on these collective experiences together, and she raised other engineering experiences in her life.

Mariabella, an annoyed coder

After working with Mariabella for two years in the community engineering program, I was interested in better understanding her disinterest in engineering. When she became a focal participant in my study, I asked her about when she said, "I love people, but I hate technology." Mariabella responded:

> **Mariabella:** Like, obviously I like my phone. But I don't like computers…I feel like looking at them is just like, so boring and…just sitting there like, trying to program

something is so boring. Like, I used to have a coding class and I know that's part of engineering. I hate coding so much. It's just like, so... What is it called? I'm trying to think of the word. So tedious//

Author: What did you not like about it? So, it was tedious.

Mariabella: Yeah. The fact that like, you just had to like, sit there and then, "Oh, snap. I messed up." Like we coded and then we also used this app called Sketch Up// Yeah, that's what I would do, and I'd just like, it's so annoying. I don't like that. At first, like in the beginning of the year, we did coding. Half of the year we did coding and then we started doing Sketch Up. I didn't like that at all (laughs)

Author: What did you not like about Sketch Up? Or what was irritating about it?

Mariabella: The fact like, that I had…mess up and like, I had to like, "Oh my God. Now I gotta go back and fix it." It's just so annoying, and like, the computer's just annoying. The computer itself. (Mariabella Transcript, 02/13/2020).

In this example, Mariabella described an experience working with her coding class at school, engaging in coding exercises and 3D-modeling. From her perspective, she described a space that constrained her agency. To Mariabella, what was irritating about the space was "just sitting there" and doing the work incorrectly. Mariabella implies there was some "correct way" she was supposed to code or play with 3D-modeling. From a structure-agency perspective, the curricular structure around coding and 3D-modeling appears to have constrained the way Mariabella could participate in the activity. To be clear, there could be several reasons why a teacher might constrain students' agency in particular ways (if – indeed – that is what happened in this case). However, what is important in Mariabella's discussion of her experience is that this seemed to lack purpose for her, as she describes it as "boring." For Mariabella, the curricular structures did not elicit much engagement or offer her much connection. She raised this coding experience as a way she disconnected from engineering. Her experience here raises a question – what would curricular structures in this coding class look like that supported or engaged Mariabella, and those like her, in a way that was meaningful to her?

Mariabella, an engaged designer

Taking an example from another context, we might explore the potential benefits of engineering learning environments designed to accommodate youth agency. In the community engineering program, youth perspectives and community data shaped the process of defining the project focus. Focal youths' experiences informed the questions, *What is problematized?* and *Who are the stakeholders in this problem?* For example, Mariabella and her colleague Ava leveraged their community experience during brainstorming sessions about problems in a local park. In the discussion, both exercised agency in raising concerns they have about the direction of the design excluding displaced persons in the park:

Author: Ok, what other problems are you all raising?

Ava: So, there's a lot of homeless peoples that hang around there. And someone asked how could we reduce this problem. But at the same time, **I don't want to look at homeless people as a problem**…

Mariabella: **Yeah, that's not a problem…like if anything, we should make it for them**…

Ava: …more like, we should make it welcoming for them, not like, "Oh they're fixing it, so now we have to go somewhere else."

Author: So, I'm wondering there if there is any issue of safety…

Mariabella: That's basically, **no that's basically who we are fixing it for**…the homeless people there…making it more welcoming so that they will like want to come there to like meditate, or whatever. Like why would you want to get rid of them, **it's their community too… They're basically the ones who go visit there and they take their naps there…why would they want to lay down in litter?**

Author: Ok, for sure. So… I'm hearing you say is welcoming for those there long term [in the park], and I'm also thinking there's a safety question or concern there in terms of the trash if there's glass or…

Mariabella: Yeah, I saw shattered glass, yeah. (Transcript, 07/17/18).

Here, Mariabella and Ava reposition displaced persons as potential stakeholders in the design work. Responding to Mariabella in the moment, I initially tried to frame her and Ava's conversation as one about safety (broadly) for all park goers, including displaced persons. Frankly, my lack of specificity was wrong and stemmed from my often neoliberal engineering training around who designs are for [9], [31]. Exercising her agency, Mariabella urged me (and the group) to consider the displaced persons in the park as particular stakeholders in the design, with distinct needs and requirements. It led us to a distinctly different design space. We documented this idea on the brainstorming paper in the moment. The group later took up Mariabella's idea by 1) including the displaced persons in the park amongst the different populations we surveyed for the design, which led us to 2) focus our design efforts on seating in the park.

The structures of Mariabella's and Ava's peers could have constrained this suggestion through disagreement or challenge. As the people enacting the curriculum, the group leaders and I could have constrained Mariabella's suggestion, either by not engaging Mariabella's suggestion or locating it beyond the project's scope. My own biases and blindness to the distinct needs of displaced persons in the park could have diminished Mariabella's nuance in her suggestion. Although this conversation was a short snapshot in time, it represents a moment where a connection might be forged or lost.

Mariabella raised this experience years later when reflecting on her engineering experiences. In the following excerpt, she responds to a prompt about engineering being important in her life (to which she could also respond "no answer"):

Author: Ok, so engineering is an important part of [your] life because...

Mariabella: It allows me to help the community, like, in a way.

Author: Can you say more?

Mariabella: Like, us building the bench... Well, we saw homeless people like, laying on, laying on the floor and stuff 'cause there wasn't any benches. So like, I hope that like, um, instead of laying on the floor I hope they go and sit on the bench 'cause they shouldn't be laying like, where like, all those bugs are and stuff (Mariabella Transcript, 02/13/2020).

This moment, deciding where to focus the design and who the design is for, seemed to hold some meaning for Mariabella. Years later, she pointed to it as a way she felt she helped her community through engineering. For Mariabella, who is passionate about her community and service, the curricular structures appeared to allow for connection to engineering. Yet, this example is about

the front-end of design work. Her experiences here also raise a question – How might designing for youth agency in all aspects of engineering design, and other engineering experiences, support engagement in engineering?

Implications and Future Work

Interrogating the structures at work in engineering experiences and how focal youth exercise agency amidst these structures reveals ways youth may come to see value– or not – within engineering. Mariabella's past experiences with, or knowledge of, techno-focused, narrow constructions of engineering contributed to irritation and disinterest in the field of engineering, *writ large*. Winking to the title, these experiences might have burned a potential bridge for Mariabella to connect to engineering. In contrast, Mariabella discussed the value of working in the more open design context, where the group took up her idea as a meaningful experience.

Mariabella's experiences offer insight into what it might take to engage more youth from marginalized backgrounds in engineering. Designing and developing ways for youths' knowledge and experiences to not only be elicited, but also have an impact is one direction that may support more youth connecting with engineering. Borrowing from science education:

> …lesson planning for agency requires teachers not only to allow space for students to exercise control over their own commitments to knowledge, but also to imagine students as specific agents and plan for the ways in which they might reframe what counts as a read-aloud, hands-on exploration, or book writing, thus designing flexible structures that can be refined through young students' participation [13].

Taking this quote into Mariabella's examples, designing engineering experiences for agency might involve allowing Mariabella greater control over what was "right" and "wrong" in her coding or 3D-modeling. In the community engineering program, it may have been reframing what "Defining an Engineering Problem" might have been to include her idea flexibly. What could this look like in other contexts or spaces?

To extend this work, I am analyzing the remainder of focal youths' cases, and looking at the nature of youths' engagement in both front-end and back-end design work. Further, I am continuing to analyze how youth discussed themselves in relation to engineering in our conversations. From these analyses, I am developing a set of considerations for pre-college engineering outreach, leveraging theories that center social justice in design [31]. To engage all youth in engineering, not just those who like coding or building, it is necessary to look critically at the practices and information valued in engineering and how these translate into the programs youth may experience pre-college. This work aims to contribute to educational designs that reflect the breadth of ways engineering can meaningfully interact within communities, both with and beyond technology-focused approaches.

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