Journal of Pre-College Engineering Education Research (J-PEER)

Volume 11 | Issue 1 Article 14

2021

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Recommended Citation

Charmaine Spruill, N., Hennessy Elliott, C., Della Volpe, D., & Alcantara, K. (2021). Engineering Care: How Two Young Women of Color Establish Positional Identities in a Robotics Space. *Journal of Pre-College Engineering Education Research (J-PEER), 11*(1), Article 14.
https://doi.org/10.7771/2157-9288.1299

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Keywords

STEM equity, engineering identity, microethnography

Document Type

Special Issue: Asset-Based Pre-College Engineering Education to Promote Equity

Cover Page Footnote

Thank you to the NYU IAL community for engaging with our thinking about this project on many occasions. Thank you to Turing Robotics for giving us the space to learn from your practice. And thank you to the editors and anonymous reviewers who gave this paper important feedback, with care, that made it much better.

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Available online at http://docs.lib.purdue.edu/jpeer

Journal of Pre-College Engineering Education Research 11:1 (2021) 256–275

Engineering Care: How Two Young Women of Color Establish Positional Identities in a Robotics Space

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Abstract

This paper examines video data of a high school robotics team to explore practices that empower youth from underrepresented groups in engineering to disrupt traditional boundaries around what engineering is and who is considered competent to participate in its practice. We analyze in-the-moment positioning work with a focus on care and maintenance practices to understand how two young Women of Color author and negotiate positional identities as part of disciplinary practices. We argue that they co-author programming positional identities by crafting a local relational space, or a comfort space, through resonating acts of care for each other's development. A more equitable future for engineering education requires an expansive vision of engineering that explicitly includes notions of what is cared for and the kinds of identities it offers to whom, and why.

Keywords: STEM equity, engineering identity, microethnography

This paper explores how two young Women of Color experienced becoming coders on a high school robotics team. In reimagining STEM education and considering what is needed to create a truly inclusive future, we examine a particular learning space that promotes the healthy development of these young women as engineers. We analyze the experiences of these two youth to largely address how female STEM Students of Color author positional identities to develop and thrive for future success in a disciplinary field typically dominated by masculinities and whiteness.

> *They saw me as a female coder – they were like "look she's a female and she codes…" When you put it that way, it can mean so many different things in so many different ways… how it is presented to people and how it can be represented in so many different contexts is important. – LC [an Afro-Latinx youth reflecting on her STEM experiences after reviewing video data]*

LC joined the university research team (Nyissia, Daniela, Colin) initially for a discussion about analysis that included watching video data of her high school robotics team practice recorded two years prior. We (Nyissia, Daniela, and Colin)

The first three authors contributed equally to this paper; the 4th author was a participating youth on Turing Robotics.

http://dx.doi.org/10.7771/2157-9288.1299

are in debt to her brilliance and ability to reflect on her experience across space and time. Her work was so influential that she is the fourth author on this paper. She is still referred to by a pseudonym just as all people and places are in this paper[1]. Now a computer science and computer engineering major at a local university, LC's comment above addressed how she felt being explicitly characterized as a "girl coding [the] robot." Her reflective comments upon reviewing videos of her experiences as a nascent coder reveal a rich, nuanced perspective on the relationship between identity and a disciplinary engagement in engineering. Being seen as a female coder can mean "so many different things" depending on the context and its presentation. For young Women of Color like LC, taking on the identity of being a programmer relies on ongoing relational work that consistently reconstructs how others see them in particular contexts. This paper explores how LC and a fellow young Woman of Color, Nicole, experienced becoming coders on their robotics team. We purposely tend to how these young women confronted the traditional notions of domination and competition. Aiming for a more equitable future, we aspire to learn from how they subverted these notions undergirding engineering disciplines. We see this in service of the larger question: How do we support the spirits and the energies of budding Women of Color engineers in education and beyond in an anti-Black, anti-women world?

Engineering learning spaces have the opportunity to promote equitable disciplinary visions and practices of engineering. Yet many inadvertently reinforce a gate-keeping notion of engineering that maintains access to certain individuals who have historically been represented. As scholars have shown, this maintains a discipline that is much harder for young Women of Color to learn and thrive in. Systemic privileges offered to White youth and young men perpetuate social harms by othering youth from traditionally marginalized groups (Calabrese Barton, & Tan, 2019; Vossoughi, Hooper, & Escudé, 2016) in STEM and engineering.

Burgeoning informal STEM learning spaces have increased some youth's engagement in engineering education before they graduate high school in the United States. The effects of the maker movement for instance, has proliferated different kinds of educational makerspaces across the country (Peppler & Bender, 2013). These kinds of informal, out of school learning spaces have the opportunity to improve access and engagement in Engineering. Yet "barriers to equitable opportunities in STEM persist" (Calabrese Barton & Tan, 2019, p. 617), particularly for Black and Latinx youth. Engineering education (and STEM education) continues to discipline non-men and Youth of Color out of thinking they belong. Changing this reality cannot be done by providing access, or representation alone (Sengupta-Irving & Vossoughi, 2019), but requires expanding visions of the disciplines of STEM (Medin & Bang, 2014) which step towards rectifying the histories of oppression and violence on which STEM disciplines reside. This includes expanding what is recognized as engineering. In other words, an asset-based focus on making engineering education more equitable requires a reimagining of the disciplinary practices themselves. To further imagine what this can look like, we explore how a disciplinary engagement was produced by the two focal young women in an informal STEM learning setting.

There has been a rapid increase of competitive robotics teams at elementary and secondary school levels. High school robotics teams are important pre-college engineering learning spaces for, but not limited to, youth who will go on to major in engineering or other STEM fields. Indeed, they are sites of STEM future production for so many youth. Informal STEM learning spaces, like these robotics teams, can expand the larger construction of what engineering is and who belongs in it, further facilitating educational equity in a different way than formal learning spaces can. They are primed to engage with the kinds of practices that Youth of Color, particularly Women of Color, bring to resist the barriers to their full performance as STEM-interested youth. Young women, for instance, might perform and experience what could be perceived as gender in/authenticity, what Faulkner (2009) defines as the "apparent congruence" and incongruence between gender and engineering identities for men and women.

Here, we surface the relational and caring work of two Latinx young women and postulate what and how learning spaces can engage in the broadening of engineering as a discipline. We build on what Vossoughi, Jackson, Chan, Roldan, and Escudé (2020) posit,

> "While we share an interest in the ways implicit relational knowledge can open up increasingly generative educational interactions, understanding learning as political and ethical also leads us to consider the forms of implicit relational knowledge that accrue from ongoing experiences with structures of power." (p. 6)

We explore the implicit relational knowledge as formations of care, both embodied and dialogic, as they resonate through LC and Nicole's ongoing experience. Here, care is not neutral (Puig de la Bellacasa, 2017) but a political force for engaging with, and shifting, power structures for STEM learning. This leads us, as Vossoughi and colleagues also note, to consider the political and ethical practices of youth as assets. Their caring practices open up room for developing forms of identities

[1] Unless otherwise specified, we use the pronoun "we" to refer to all four authors.

in relation to engineering practices. In this way, we characterize youth's assets in engineering learning spaces as resources for developing emerging parts of their identity and reinventing the disciplinary boundaries. The youth's assets we focus on, therefore, are the resources youth deploy for developing disciplinary positional identities (Holland et al., 1998).

Socio-political Issues in STEM Literature

A specific subset of scholarship has taken on the challenge of exploring sociopolitical and sociocultural perspectives on the STEM educational experiences of Black, Brown, and Indigenous youth including specifically young women and girls. This body of literature makes two things clear: equity and justice requires subverting larger narratives that limit who can participate in STEM (Sengupta-Irving & Vossoughi, 2019; Vakil, 2018; Calabrese Barton & Tan, 2019; Greenberg, Calabrese Barton, & Tan, 2020), and disciplinary boundaries must be "unsettled" (Bang et al., 2012) from their settler colonial logics by engaging with non-dominant ways of knowing (Bang & Marin, 2015; Eglash et al., 2016; Eglash, et al., 2013). Further, Ma (2016) and DiGiacomo and Gutiérrez (2016) argue that equity should be viewed from a relational perspective that clamors for all learners to "have access to learning, not despite, but because of their diverse repertoires of practice and histories of engagement in cultural practices" (Ma, 2016, p. 336).

How youth engage in disciplinary work rests on what kinds of practices they have access to learning, how those activities are positioned in relation to the disciplinary notions, and, as Agarwal and Sengupta-Irving (2019) point out, the ontological and epistemological relations that undergird such collective positioning. Not reproducing the epistemic violence of limiting visions of disciplines and instead embracing practices that bridge youth's experiences with disciplinary learning (Nasir & McKinney de Royston, 2013) requires spaces that invest in a diversity of epistemologies and ontologies. Creating these kinds of spaces gives room for traditionally minoritized youth to develop a "rightful presence in STEM" (Calabrese Barton & Tan, 2019). Sengupta-Irving and Vossoughi (2019) frame dignity as a social practice. We build with these socio-political perspectives on educational justice by engaging in the stories of one of the authors and another young woman to understand the possibilities of their identity construction in relation to ongoing forces of social power. To do so, we add a conceptualization of care (Noddings, 1986) that attends to the interconnectedness of the social and the material ecologies of their practice (Puig de la Bellacasa, 2017).

Below we present microethnographic analyses of LC's high school robotics team (Turing Robotics, or TR), supported by discussions with LC and Nicole in various times and spaces after the focal activities occurred. We analyze how they authored roles as programmers by focusing on specific moment-to-moment moves within the larger material, social, and historical ecologies. Specifically, we identify the social and material moves that make up local acts of care which support the collaborative production of disciplinary identities located in durable, contextual, and social positions (Holland & Lave, 2009). Therefore, inquiry starts from the questions: How do Nicole and LC author positional identities specific to becoming programmers? How does their social action push on notions of what is typically represented by engineering disciplines?

Setting: Emerging Programmers in Turing Robotics

Data were generated with the Turing Robotics community, a robotics team which participates in FIRST robotics competitions (FIRST, 2020) and is based at Turing High School. Turing High is an engineering focused school that serves youth from every part of a midsized northeastern city. Over the four years of data collection, Turing Robotics was a "team-focused" makerspace (Hennessy Elliott, 2020a) equipped with multiple machines and various engineering, metal working, and woodworking tools. The goal of the team was to design and produce a working robot that can operate autonomously and be driven by operators at competitions. Youth had opportunities to learn to use large metalworking and woodworking machines, as well as the computer software that makes design and production possible. When they started, youth were given options to decide on the kind of work they wanted to participate in which included: designing, fabricating parts and building, electrical wiring, programming, organizing and fundraising, driving and operating, and strategizing. Many youth chose more than one activity to learn during their time on the team. Youth opted-in to participating in Turing Robotics, and had the option to decide not to continue at any time.

Turing Robotics, like Turing High, was made up of almost exclusively Black and Brown youth. Many participants on the team over four years of ethnographic work identified as descendants from a specific Caribbean, Central American, or South American country while a few identified as Black. As Youth of Color, at competitions, they encountered a vast majority of teams that are majority white and male. In the year of focus in this paper, there was a growing number of young women on the team, including co-writer LC[2] and Nicole. Part of this growing participation of young women, especially

[2] LC became the captain of the team the year after the focal episodes in this paper occurred.

in the more technical aspects of the team, built on the previous participation of a few young women in key positions (see Hennessy Elliott, 2020a).

Turing Robotics had never had young women act as the team's "coders" or programmers before LC and Nicole. It had always been a combination of a young man and a mentor. The year before the focal episodes in this study LC began taking on the role of programmer after the lead programmer graduated. She struggled that year to take control of the code and be recognized in relation to her expertise. Yet the next year – the one where the focal episodes occurred – LC developed into the role of the "lead coder" with Nicole as a close collaborator and fellow coder. Nicole, a 9th grade newcomer to the team at the time, shared in a group discussion two years later: "I realized [at the beginning of the season] that I wanted to learn from LC and Lando (mentor) because I wanted to learn coding."

This paper shares three separate episodes that spanned about ten days of team practice where Nicole and LC worked together on important tasks for the team. They worked in conjunction with their mentor (Lando), their coach (Mr. Merkur), their captain (Jav), and a few other youth on the team. In the first episode, they worked with other youth to construct the electrical system on an old robot that, under the suggestion of Lando, they later used as a practice robot (called Coding Robot). In the second episode, ten days after the first, they attempted to debug their code which was meant to interact with Coding Robot's pneumatics system. The third episode occurred later the same day as the second, after LC and Nicole moved to a different location to debug their program separate from the Coding Robot. Table 1 shares the prominent participants that show up in one or more episodes for analysis.

Theoretical Framework

As LC and Nicole's stories exemplify, learning on Turing Robotics is an interactional phenomenon that emerges on a needed basis. Youth learn to perform tasks on the team as those tasks become salient to ongoing practice. Learning to perform these tasks, like programming the robot, is incredibly important to the function of the team because youth who have necessary skills and knowledge eventually graduate, leaving the possibility of the team losing a lot of their experience and knowledge. Learning, much like the team's practice, is a distributed phenomenon like the work on naval ships that Hutchins (1995) studied. Youth learn by being with and learning from more experienced members of the team as well as mentors who deliberately offer opportunities for them to perform with technical machinery. We take the perspective that learning is a sociocultural (Vygotsky, 1978; Lave & Wenger, 1991) phenomenon as a confluence of developing participation, mentorship, and material feedback (Manz, 2015).

Positional Identities

We start analysis from the assumption that the social practice in Turing Robotics is an ongoing act of dialogism (Bakhtin, 1984). Social positioning work unfolds as collaborations on forwarding social and material action. Youth on Turing Robotics negotiate their roles on the team, roles which are dependent on their previous experiences with the team and without (see Hennessy Elliott, 2020a for an analysis of a different role on the team). Therefore, "what we call identities

Table 1
Participant List for all three episodes.

Name ***(all pseudonyms)***	**Descriptive Note**	**Year on the team** ***(grade, or status)***
Nicole	Emerging Programmer also interested in team organizational work; identifies as a Latinx woman.	1st (9th grade)
LC**	Experienced and emerging Programmer; identifies as an Afro-Latinx woman.	3rd (11th grade)
Lando	Mentor of electronics and programming; identifies as a Black man.	4th year as a mentor (alumni of team)
Mr. Merkur	Coach who is also an Engineering teacher at Turing High; identifies as a White man.	4th year coaching
Jav	Captain of the team who specifically leads fabrication and design work for the robot; identifies as a Portuguese-Brazilian man	4th year on the team (12th grade)
Damir	Newcomer to the team interested in design and build; identifies as a Black man.	1st year on the team (9th grade)
Nick	Oldtimer on the team who has mostly worked in design and build practice; identifies as a Latinx man.	3rd year on the team (12th grade)

***The 4th author on this paper due to her contributions.*

remain dependent upon social relations and material conditions," (Holland et al., 1998, p. 189) which are authored into the local practices of a social space and durable, collaborative, and co-constructive.

Holland et al. (1998) delineate figured and positional notions of identity to explore the relationship between one's negotiation of larger social narratives and the ongoing, moment-to-moment, relational work of acting in the world. Positional identities "have to do with the day-to-day and on-the-ground relations of power, deference and entitlement, social affiliation and distance… with the social-interactional, social-relational structures of the lived world" (Holland et al., 1998, p. 127). We take on their notion of positional identities to illuminate the social and material conditions and the particular moves that LC and Nicole participate in to author themselves in the role of programmers on Turing Robotics. We examine video of Turing Robotics' practice and youth's reflections from recorded discussions at three different points in time afterward to paint a picture of their emerging positional identities as programmers. These disciplinary positional identities – programmer positional identities – have the possibility to reinforce, or become ruptures of, local history on the team as well as racialized and gendered narratives, as Wright and colleagues describe was the case for an engineering teacher in a professional learning community (Wright et al., 2019).

When considering their positional identities, we take into account how Nicole and LC are authoring their roles into the space in these micro-moments and the kinds of positions that others help to craft. In other words, what kinds of identities are available for them and what kinds are they directly implicated in making space for?

Acts of Care: Amplifying and Resonating Notions of Who Can Contribute

In preliminary analysis of the data, we witnessed the unquestionable importance of LC and Nicole's unfolding relationship for how and where they developed in the roles of programmers. Their friendship became a relational resource for identity making and furthering joint work. Particularly, their acts of sustaining each other's continued place of expertise in the space relied on affective moves that we frame as *acts of care*. Care is an underused analytic frame for exploring learning interactions because it is often either taken for granted or entirely ignored for an orientation towards the content learned (Noddings, 1986). There is a lot to learn from Nicole and LC's stories about the relational nature of learning and developing in informal engineering learning spaces. In analysis, we argue that the care practices of Nicole, LC, peers, and mentors – assembling acts of care – construct a space where Nicole and LC can feel comfortable to enact particular positional identities.

Noddings (1995) posits that no matter what identities youth enact, they all need to be "cared for" as part of the learning process calling for relations to be centered in educational practice. Krist & Suárez (2018) characterize Noddings' theory of care as "an orientation to concern for collective well-being in relationships," (p. 424) an orientation that surfaces a "fidelity to persons" (Noddings, 1986) to guide actions in learning interactions. The notion of care as a resource for learning has been taken up by a small, but growing, corner of the field of education research (Krist & Suárez, 2018; Phillips & Lund, 2019; McKinney de Royston, et al., 2017). As an example, Vossoughi and colleagues (2020) describe the implicit relational work as a creation of "ethical trails" through embodied pathways of participation.

Puig de la Bellacasa (2017) argues for developing speculative notions of care that recenter the complex relations between humans and non-human agents, or what others might label as material and ecological contexts. They argue for reimagining care as an outcome of ongoing relations across human and non-human boundaries. We lean into that charge to pay attention to the complex interconnected nature of the relationships in Turing Robotics as part of an analytic frame on how caring relations unfold for LC and Nicole. Care is a sociomaterial practice.

We draw from Noddings' (1995) vision of care as the relational orientation towards well-being with Puig de La Bellacasa's (2017) conceptualization of care as an intertwining of human and non-human relations. Care, here, is an ongoing socio-political intervention that offers new forms of what matters in the space and what identities youth can co-create. We see these *acts of care* as moves to sustain – or dampen – relational resonance towards a fidelity in persons. Care as a resonating social phenomenon builds on Phillips and Lund's (2019) conceptual frame that identifies how specific social acts sustain "affective resonance" which creates and sustains an ethos of care. The authors use an analogy that considers the ways in which sound can echo, propagate, and reverberate when sustained by certain material and human configurations. This analogy is brought to mean "how the culture of affect came to move, echo and be sustained in [the] space" (p. 1535).

What and how acts of care amplify and resonate LC and Nicole's relationship, for example, proved to be an important inquiry into how they constructed their positional identities. We conceptualize care as an ongoing work of and across relations that co-produces what matters. This could be through the power of touch (Goodwin M. H., 2017), generative support, or even affirmations that help another matter. In analysis, we look for moments in Turing Robotics practice where acts of care thicken the relational web that youth drew from to author and sustain their disciplinary positional identities as programmers.

Resources laminated from the interactional substrate

Drawing from C. Goodwin (2017) to analyze social interaction, we argue that action is co-operative and deployed by actors across space and time through the inhabiting, decomposing, and recomposing of previous actions. Each new action is created by building on previous actions, transforming either in-the-moment resources that emerge in interaction or resources produced by earlier actors in a past time and/or in another place. Therefore, relational work is iterative and builds on previous actions, relations, and material ecologies that make up what C. Goodwin (2017) refers to as a substrate. We use substrates, and their laminations, as a unit of analysis, seeking to make sense of the social actors' contributions as part of a complex spatial and temporal layering of action.

Laminations (C. Goodwin, 2017) occur when interactional resources (including narratives and materials) are brought to bear across different mediums and layered in relation to other resources. For instance, while analyzing expert and apprentice archeologists working together in an excavation field, Goodwin considers the different meaning-making resources used by participants in interaction. Each gesture, each turn in talk, and each action builds on a variety of interactional resources made available by others. Laminations undergird the positional moves that Nicole, LC, and their peers and mentors make as part of the joint work of a robotics team practice. Therefore, we look for how resources are drawn from the larger material and immaterial substrate that sustains social action, particularly social actions that resonate as acts of care.

In the episodes below, specific materials get reified as important to furthering joint activity. These materials – for instance a screwdriver to help with wiring the robot, or a joystick to test the connection between the programming computer and robot – bring their significance to the activity as they change hands, laminating the ability to contribute to those who have physical access to them and to use them in ways deemed appropriate. Their power becomes part of the substrate that social actors take up, remake, and laminate as part of moving action forward. The joystick has particular power in furthering joint work, for instance, because it laminates a notion of who has control of the robot. Below we refer to these materials as "power-laden materials."

Methods of Analysis

Data for this project come from a larger digital video ethnography (Goldman-Segall, 1998) where Turing Robotics practice was video recorded in an emergent fashion, depending on Colin's (coauthor) interpretation of what was happening in the moment as a mentor-researcher. Generative conversations with youth about their experiences on the team were also part of this larger study; we employ data from one of these conversations that included Nicole and LC (coauthor) around the time of these episodes to thicken analysis. Colin also performed multiple video elicited discussions with LC and Nicole two years after the focal episodes occurred. Further, LC continued to stay involved in analytic discussions throughout the writing process of this article. Cutting across space and time, we develop analysis with Nicole and LC's reflections paying attention to the different positional identities they take up in these conversations in relation to the research and researchers discussing their experiences. These different levels of participant reflection on experiences helped us notice how specific kinds of care were constructed between Nicole and LC that were not as visible in the video record. Further, it helped us question how care was becoming part of our role as researchers.

We use microethnographic methods (Erickson, 2004) to explore the social practice of Turing Robotics. This included selecting two specific video recordings to perform iterative analytic cycles on which entailed: transcribing (with methods based on Jefferson, 2004), reviewing, annotating and editing the transcription, reviewing again, and so on. These data "hotspots" (as Ma, 2016 describes) were selected during an initial review of the corpus for recordings that included both LC and Nicole. The first was initially highlighted by Nicole, and then LC, who reflected during the next season that previously wiring the practice robot was very influential in their learning how to program. Reviewing the data, we realized that this practice was the beginning of Nicole's participation trajectory from simply observing to taking a leadership role – with LC – in programming and debugging the robot's working code. The second hotspot comes from team practice ten days later where LC and Nicole, together, debug their programming attempt by testing the physical connections and, later, their code's logic. We selected the three specific episodes from the analytic hotspots because each shares important moments in the trajectories of Nicole and LC, together, as programmers on the team. Further, they depict visible acts of care between each other, other members of the team, and the material ecologies they work within. The first episode comes from the first hotspot, showing a moment where LC and Nicole supported each other in wiring the practice robot with some teammates as a mentor looked on. The second and third episodes come from the second hotspot when Nicole and LC debugged programming issues by first testing the wiring (episode 2) and then comparing their program to other sample codes on the internet (episode 3).

In the tradition of Interaction Analysis "dedicated to collaborative, interdisciplinary analysis" (Jordan & Henderson, 1995, p.45), we took these episodes to larger collaborative data viewings sessions with colleagues to garner different perspectives on the interactions. Close attention was paid to participants' short segments of talk, embodied behaviors and use of artifacts and tools in the episodes' video clips. They were also examined together with ethnographic data from observation and interviews.

We employed repeated viewings across multiple groups of analysts and grounded our theories in the video data, with the goal "to identify regularities in the ways in which participants utilize the resources of complex social and material world of actors and objects within which they operate" (Jordan & Henderson, 1995, p. 41). After multiple rounds of transcriptions and viewings, we produced inductive coding of the episodes as in-vivo codes (Saldaña, 2013) of discourse, gestures, and the interactional substrates. These codes aided in making sense of the interactions across all three of the episodes. Table 2 represents examples of the codes that came up in these passes and were used for further analysis.

Author positionality

To iterate on our analysis further, we welcomed LC (coauthor), who had since graduated from Turing High, to engage in analytic discussions where we 1) reviewed the episodes, 2) discussed our emerging analysis, and 3) heard LC's own retrospective analysis as a new layering of her authoring of a positional identity. It is important to note that LC was already experienced in analysis of video and ethnographic data from her participation in an adjacent participatory action research project. We were unable to meet with Nicole after the analysis process had begun. Below, we, as authors, each briefly introduce our positionality to this project.

I (Nyissia) am an English Language Learner teacher and coordinator pursuing a doctorate in early childhood education. I identify as a Black woman, with multi-generational roots in the United States. I began collaborating with this research work after the initial video data collection, learning of Turing Robotics and its participants from video recordings as well as conversations with collaborators Colin and Keidy.

I (Colin) am a former physics teacher who worked as a mentor and participant researcher with Turing Robotics for four years. I recorded the video data and conducted the interviews that we use as data. As a cis-gendered White man, I understand that I may not always be able to fully represent the experiences of the Black and Brown young women, like LC and Nicole, that I worked with on this project. The collaboration this paper comes from is an attempt to learn from them, not directly represent them or the complexity of their experiences of inequity and resistance.

I (Daniela) am a former mathematics teacher, currently pursuing a doctoral degree in education. I identify as a White woman of European descent and upbringing. I joined this research work in a secondary research phase, not having participated in the original study that this project stems from. My knowledge of Turing Robotics and its participants only comes from video recordings, with the exception of having the opportunity of working with (Colin and Keidy) as a collaborating author.

I (Keidy) am a computer science major at a local engineering university. I was a participant on Turing Robotics and a youth researcher on a connected research project. I identify as an Afro Latinx person. I participated in the original study as

Table 2
Examples and explanations of in-vivo codes produced in reviews of the episodes.

In-vivo Code	Meaning and reference
Vision	Physical and social references to what participants can see in interactions; "I can't see because his hands are in the way" (episode 1); "look at that…" (episode 2). This later becomes important to understand what it means to be seen in a particular role on the team.
"Wanna try?"	An utterance or gesture where one participant offers another an opportunity to attempt a task. For example, LC offer's Nicole the chance to attempt the task in Episode 1 handing her a screwdriver and says "wanna try?"
We vs. you	Participant references to others, present and not present, as including themselves (we) or excluding themselves (you). In episode 3, LC and Nicole refer to programmers on other teams who have shared their work on the internet as part of a we (collective group of FIRST programmers) and you (another team).
Material power	Participants in an interaction reify the power of a particular material artifact as important to social action. The screwdriver in episode 1, and the computer and joystick in episodes 2 and 3 are examples of materials that drew this label.

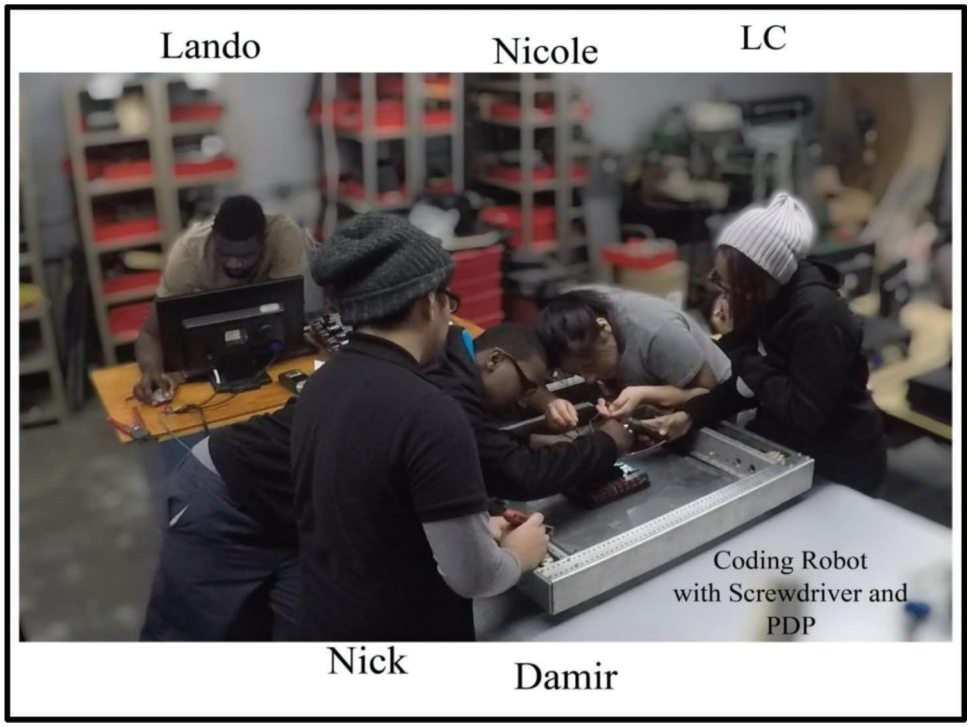

Figure 1. Actors in Episode 1, shown as Nicole stepped in to attempt the task. Just after this frame, Nicole shared that Damir's hands were in the way.

shown in the video recordings of my high school years as a member (and later team captain) for Turing Robotics. I was one of the participants who were active in commenting and giving feedback to Colin when he first started his research.

Findings

Below we share three episodes of team practice that characterize – but do not wholly represent – LC, and Nicole's positional work becoming the team's coders. Focusing on the productive and resonating network of caring relations they stitched together, we argue that they co-authored their positional identities as programmers conjointly. In Turing Robotics, taking on a role requires the display of your knowledge and abilities to contribute to future team practice. Therefore, authoring a disciplinary positional identity requires some public production and display of abilities. This production can run against the "authenticity" of youth' emerging position in relation to oppressive narratives about gender or race (Faulkner, 2007). The invisibility of some of Nicole and LC's work as programmers acts as a resource for their collaborative creation of what we are calling a *comfort space,* or a relational space produced out of the larger disciplinary space through acts of care. Yet they still make their emerging roles visible including when they learn to wire electronics and when something needs to be debugged. How authored positional identities reverberate through a community like Turing Robotics rests on a collective outcome of them being seen and being valued. These episodes were selected to depict moments of such reverberation to learn from the brilliance of LC and Nicole's navigation of their work and how the larger community supported it.

Episode 1: Need to know how the system works

In the first episode, Nicole and LC (coauthor) joined three other youth and Lando (a mentor) in wiring the electronics on an old robot (see Figure 1).[3] We look to this episode to understand how LC and Nicole co-authored their positional identities of being programmers through their collaborative work on the wiring of this robot, the Coding Robot.

On a January day early in the competition season for the team, Lando recruited LC, and later Nicole, to join in gathering materials and wiring an electrical setup for an old robot system. He wanted it to become a practice robot for the programmers, (referred to as the Coding Robot). He articulated that the emerging coders, particularly LC and Nicole, should join the work in putting together the wiring because,

[3] Colin (coauthor) has explored a case from this same activity with a focus on the material relationships as part of a different analysis (2020b).

> **Lando**: "…you have to know how the body and the system and the mind works before you send code to it… ***If you know how a system works you could, you could deploy BETTER code than regular***. So what we're going to do now is we're gonna make this ((points to the old robot under the table)) NICE BOY work" [by adding electronics]. (emphasis is ours)

This justification for coders to join the work positioned a pathway to physically produce an artifact – the wired Coding Robot – as part of their developing roles as programmers. According to Lando, being a better programmer meant knowing how the electronics system works so you know what your code can do. This became important later when debugging issues arose as the robot did not respond correctly to operations it was asked to do (see episode 2) and the team needed to decide whether the problem was the programming or the mechanical setup, a common debugging issue in systems set up to have programmed software drive hardware movement (also known as physical computing systems, DesPortes & DiSalvo, 2019).

Lando's framing of the activity acted as a resource in the interactional substrate for LC and Nicole. The group's negotiation of role and position over a twenty-five minute period collaboratively drew on 1) the need for LC and Nicole to have experience physically wiring the robot to be better programmers, 2) LC and Nicole's developing relationship, and 3) the unfolding material environment and social milieu.

The group of youth were tasked with collecting, attaching, and wiring the components of an electrical system that would make the Coding Robot move with programming. Specifically, they needed to wire the attached motors to the Power Distribution Panel (PDP) which organizes the electrical power between the onboard computer and the components on the robot. The computer communicates with the Power Control Module (PCM) to tell it what to power and when, as programmed and communicated by controllers and/or joysticks connected wirelessly from a laptop to the robot computer. Inserting the wires to the PDP requires inserting a screwdriver into a hole above the wire access hole and pushing in a downward fashion to open up the access hole for the wire to be inserted before letting go so that the wire stays connected.

Over the course of over twenty-five minutes, the youth attempted to insert the wires into the PDP. First, LC and Damir attempted multiple times to insert the wires but the screwdrivers kept slipping with a loud pop. Lando (the mentor) then stepped in to demonstrate, struggling a bit himself before getting the wire to stay. As he worked at the Coding Robot, Damir and Nick discussed the expense of the PDP in the event it was broken by any of them. While Lando finished up his demonstration, LC offered the opportunity for Nicole to try. Nicole stepped in and tried herself but was unable to get the wire in or even see what she was doing because, as she puts it, Damir's hands were in the way (see Figure 1). Damir stepped away and Nicole alternated attempts with him while LC and Nick supported them. Finally, Lando stepped in to complete the task himself so they could move on to another part of assembling the electrical components of the robot. Once he did this, Nicole asked to try, and then attempted to open the hole enough to insert a wire again. This time she was successful. Her success was celebrated by LC (a high five), and Damir (after he asked her "HOW?!") before they moved on with what was next.

Nicole's initial failures and eventual success was a product of shifting relationships between the materials, LC, and even Damir. It was also a material-laden action that authored her as a programmer. The authoring is a product of laminations of particular material (e.g. access to an important tool) and social resources (e.g. the notion that programmers need to know how to electrically wire the robot) drawn from the substrate of the interactions. Each of these laminations come through acts and a maintenance of care that orient what is important to further social action. Below we share a few instances that show how these moments of care unfolded and were taken up for Nicole, and at times LC, to author a programmer positional identity. These acts amplify a resonance of care for their positions as programmers across space and time (Phillips & Lund, 2019).

A powerful relational moment occurred while Lando demonstrated how to insert wires into the PDP. Lando had stepped into the position where LC was, as she stepped out of the way and closer to Nicole. During a break in Lando's description of what he was doing LC turned from looking over her left shoulder to her right, leaned closer to Nicole and softly asked, "Learning, Nicole?" Even though LC turned back to face Lando before an answer, Nicole nodded anyway. This slight check-in constituted in LC and Nicole's previous relationship surfaced a care for Nicole's learning and the relational nature to LC's interpretation of this activity as a learning moment. Nicole's gentle nod, while both of them intently gazed at the demonstration of the task, further indicated it as an act rooted in reciprocal care for their work together.

Just before Lando finished demonstrating how to insert the wires, LC interceded with a move that constructed an infrastructure of care (Puig de la Bellacasa, 2017), offering the opportunity for Nicole by saying "wanna try" and holding out the screwdriver. As pointed out in another analysis (Hennessy Elliott, 2020b), the transfer is a material-laden gesture that reconstructs the power to act in the space, which opens the access for her to try her hand at wiring. In a discussion about their practice later that week LC characterized her reasoning for this offering. When asked if she felt like she was part of the work to get the robot wired she replied,

LC: "I felt like I was a part of it [the wiring] cause I, like, I did put some things together. But I didn't wanna make it so I was doing the majority of the work. I wanted to pass it on to – I would hand the screwdriver to [Nicole] or give something to [Nicole] or to [another youth] cause I felt bad. I was like, 'come on guys.' ((gestures with hands up))

LC's interpretation of this activity in a later space and time (later that week), shows that she felt the need to be inclusive by co-constructing a space where Nicole could also feel like she was a part of the work. This reflection – and the action she referred to – indicated being guided by a "fidelity to persons" (Noddings 1986; Krist & Suárez, 2018), the commitment to the well-being of the others, grounded in a relationship of care. This commitment orients an interaction toward the success of joint work and not to the competitive individual gains of being able to perform the task herself (Krist & Suárez, 2018). Her want to "pass it on" means sharing both the power-laden tool (screwdriver) and the knowledge/experience from performing the wiring. Therefore, authoring her positional identity as a programmer meant giving room for her collaborator to join.

Over the course of the activity, the two programmers continually co-constructed acts of care that dignify and craft comfort in trying to complete the task. These acts sustained each other as nodes in a resonance of care (Phillips & Lund, 2019) that signified first LC's and then Nicole's attempts as more important than the speed that they completed the task. The materials furthered this caring construct: the screwdriver, wire, connection, and robot were all complicit in co-producing the importance of Nicole's attempts. Nicole and LC constructed, together, positional roles as programmers who can know wiring. First, Nick offered a suggestion that Damir and Nicole work on wiring on opposite sides of the PDP:[4]

1. Nick: ((to Damir)) So you do this one ((*points to black entry on PCM with screwdriver*)), and she does the red one ((*points to red entry on PCM next to it*)).
2. LC: ((*gathering the red wire*)) oh yeah. So. Wanna do it? ((*holds the screwdriver to Nicole*))
3. Nicole: Sure. ((*reaches over and grabs the red wire*))
4. LC: ((holds up the screw driver again)) and then do it with this one.
5. Nicole: Alright.

While Nick offers a solution for multiple people to try the task at once, LC offers, again, for Nicole to step in and try [line 2], even gesturing with the screwdriver that Lando had used and given to her [line 4]. As she began to attempt the task, it became clear that she could not see what she was doing (moment shown in Figure 1). Each took a turn trying to fix this issue.

11. Nicole: Wait wait. Wait LC. Wait take it off for a second.
12. Damir: LC.
13. LC: Wait can you see? ((*quiets voice*)) what the fuck. ((reaches and grabs her phone))
14. Nicole: I'm gonna wait till he's done [cause his hands are, like, in the way.
15. Nick: [how many more
16. Damir: My hands are not that large.
17. Nick: Wait wait. How many umm. Do you have to connect.
18. LC: ((turns on phone flashlight)) I'm just gonna do that. Ha ***[[moment depicted in figure 1]]***
19. Nick: Four
20. Nicole: Ok. I'll wait
21. LC:you can see better
22. Nicole: Yeah, there are. I can even like ummm
23. LC: Yeah hold up. Wait.
24. Damir: My hands are really that large.
25. LC: Yes.
26. Damir: ((*Leans back*)) Ok. Go ahead.

LC first surfaced that Nicole might not be able to see [line 13], and then tried to fix it by getting her phone and turning on the flashlight and shining it at the PDP [line 18]. As she did that, Nicole shared that she was going to wait because Damir's hands were in the way of her seeing [line 14]. Damir first contended this with "my hands aren't really that large" [Line 16]

[4] The transcripts in this paper follow a modified version of Jefferson's transcription convention (Jefferson, 2004) similar to what Ma (2017) describes. Turns at talk are designated by line number. Relevant non-talk activity such as gestures, gaze, body position, is enclosed in ((italicized, double parentheses)). Vertically aligned [left open brackets signify overlapping talk across turns, and latched turns by matching = equal signs. Louder utterances are CAPITALIZED and drawn out speech is represented by co::olons. A moment in the transcript that corresponds with a figure is indicated by [[moment depicted in Figure#]].

and then relinquished [line 24; 26] after Nicole stated that she will wait anyway [line 20]. LC's move to shine light so Nicole can see was an act of care that works to make Nicole's activity not just possible but also more comfortable. These acts of care continued to resonate with the organization of materials, with the narratives Lando, Nicole, and LC co-constructed earlier and with a notion that Nicole's place here matters. While Damir first rejected the assessment of his dampening effect on the comfort and care for her attempt (hands in the way) he eventually stepped away after asking again if his hands were so large that they got in the way [line 24]. The end of this moment, his "Ok. Go ahead," was not giving permission, but instead relinquishing his opposition to the work that LC and Nicole were doing to author Nicole as a viable actor in the space.

Nicole and LC co-authored their positions in the space as part of the mechanical work. While it is important for the group to complete the task, being in a position to attempt was most important for these two young women. The notion of trying and this kind of access (i.e., LC giving Nicole the screwdriver; Damir moving his hands) produced a resonance of care that not only continues the joint activity but also offers opportunities for both of them to further author themselves as programmers who wire the robot. LC's position at the beginning of this episode as the lead programmer was more static, and clear, than Nicole's positioning; therefore, her positioning work was choreographed in relation to offering room for Nicole to join, as her comments later that week confirm.

Nicole's position shifts across this activity due to the local co-construction of her access to attempting the practice, and the success and failures of her tinkering. It is not just important that she and LC are able to do the task. Their work on the Coding Robot is a productive practice because it offers them the opportunity to step in as programmers who tinker with the wiring and to engage in a different kind of productive failure (Kafai, et al., 2020; Kapur & Bielaczyc, 2012). The robot, as part of the substrate, is also a resource in their co-authoring of their disciplinary positional identity which continues in their future work as programmers, as shown in the next episode.

Episode 2: "Girl Coders"

Ten days later, LC (coauthor) and Nicole worked at the Coding Robot in an attempt, without their mentor present, to program a connection between a controller interface and the operation of pneumatic controls. LC stood with the laptop in between her and the Coding Robot on the table, with a cord connecting the onboard computer (connected) with the laptop. Nicole sat on a stool just next to her, in line to see the laptop screen and with a connected joystick in front of her. Since episode 1, they had worked with Lando, and other team members, to construct more of the electronics on Coding Robot, including a pneumatics set-up (Figure 2).

Pneumatic controls are used in FIRST robotics to perform specific tasks as an alternative to motors. Commands drive pistons with an onboard air compressor and a series of tubing connections that move through the pneumatic control module

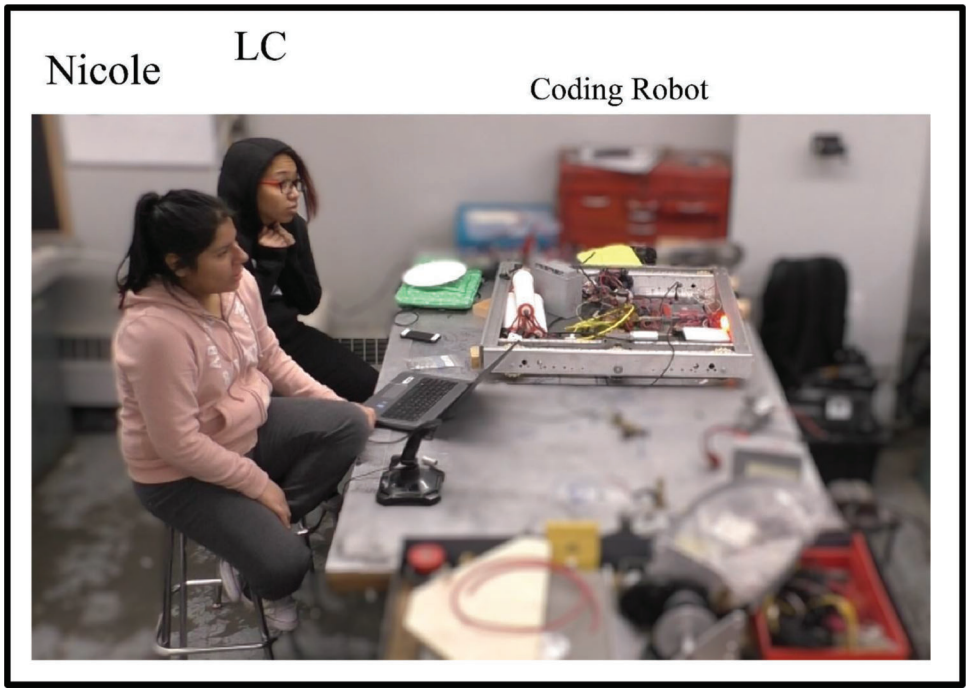

Figure 2. Nicole and LC sit at the worktable with the Coding Robot, Laptop, and Joystick controller.

(PCM) which is connected to the onboard computer. LC and Nicole, therefore, were testing to see if their current code set up the connection between a controller and the PCM. They enlisted the help of a mentor, Bruno, who had mechanical experience but little to no coding or wiring experience, to see if indicator lights turned on. When it did not indicate a correct programming connection, they debugged first the wiring to the PCM and then the code itself. This work was consistently interjected by Jav – the captain of the team – who was working on a mechanical aspect of the competition robot nearby and other members of the team milling around the shop.

At the start of the debugging process, LC and Nicole were both leaning over looking at the computer screen. Nicole's hand was pushing the joystick while LC pointed to the robot. In the background and off screen, Jav spoke to the coach. The young women looked up and Nicole responded to his comment. Jav continued to speak. LC and Nicole settled back in, LC pulling the computer closer to the two of them. Nicole looked back when she heard a noise behind her and looked at Jav who made another comment as LC continued to focus on the screen:

1. Jav: You break those stereotypes. Men can clean.
2. Nicole: ((*shaking her head and smiling at Jav*)) No, they can't.
3. LC: yeah
4. Nicole: He's right though.

Nicole turned from Jav to LC. LC pushed her glasses to her nose and continued to work on the computer. Nicole then looked, silently clapped her hands, and grabbed the joystick while looking at the computer with LC. They leaned in towards each other. LC typed on the keyboard while Nicole looked over the work. Nicole then moved the joystick around while looking over. The two backed up together and discussed what was on the screen:

5. LC: Let's see
6. Nicole: ((*claps hands*)) alright let's go.
7. LC: ... If I don't finish it, well. Ok. We need. Yes he did a lot of things he put in here are ((*muffled*)).
8. Nicole: ((*playing with the joystick*)) Well, he's right, shouldn't we put something in the finished VI for the solenoids?
9. LC: Well
10. Nicole: Nununu[nuno. Yeah. No.
11. LC: It would be a continuous loop ((*turns hands over in looping fashion*)) so that's not what we want the loop to contain.
12. Nicole: Yes.

Their disciplinary talk unfolded somewhat quietly while others in the shop worked and talked louder. Then, Jav looked up from his work and exclaimed that he just realized that the team had girls doing the coding work.

13. Jav: Look at that*, ((*LC looks up sharply towards him*))
14. Jav: I just realized, we actually have girls coding our robot. ((*LC gathers her hands into fists and places them beneath her chin, hugging into herself*)) ***[[moment depicted in Figure 2]]***
15. Jav: The other team's you'll see 'yeah we're coders', 'what's an if statement,' 'a what.' ((*LC puts her arms down and laughs*))
16. Nicole: ((*turns to LC*)) see we don't do that. ((*Nicole grabs the computer towards herself and smiles while LC bends over to hug into Nicole's shoulder. She rests on her shoulder for two seconds then looks up again*))
17. Jav: You'll see them on the computer, but if you really look at the computer they're just playing tetris. And then you'll see the mentors behind them coding.
18. ((*LC purses her lips and nods. Nicole is turning towards LC as she stretches her back. LC looks back down at the computer. Nicole looks at Jav as he continues to speak.*))

By sharing the notion of "girl coders," Jav inhabited his previous reference to "breaking stereotypes." Further, Jav's interjection in the middle of them discussing programming strategies [lines 1-12] to try not only noticed LC and Nicole as girls, but also as "actually… coding our robot," or in the role of programmer. Allusions to noticing and observation were fraught within the video recording. Whether in dictating where to focus attention or noting what can be viewed or has been viewed by others, seeing, noticing, and looking were integral parts of the social action [lines 3; 5; 6]. What one views can help one understand what and how they are learning; indeed the ability to direct one's attention for the purpose of edification is empowering and allows others to be empowered.

Nicole and LC made particular social and gestural moves to develop care and comfort in making mistakes as they worked. For instance, when Jav initiated his comment, LC first did a self-hugging gesture (see Figure 2; line 14) then laughed at Jav's comment that some girl coders won't know what an if statement is (line 15) and then laughed and hugged Nicole's shoulder for a bit after she commented "see we don't do that" (line 16). Made just after some disciplinary talk was interjected, these gesture moves highlight the intimacy and comfort LC and Nicole shared as an internalized substrate used in the co-production of their learning as coders. They were able to create a relational space where they felt seen, heard, and were positively acknowledged in their coding learning process.

The spatial and material choreography between LC and Nicole facilitated their co-authorship as budding engineers. Interactions with the computer and joystick (power-laden materials) highlight a dominance of taking and grabbing between the two young women during the engineering process. For instance, Nicole played with the Joystick (line 8) even when the connection would legitimize her access to the material and performing the debugging activity while asking why it will not work. Later, the interplay between Nicole and LC around the computer, just after Jav's comment, (Nicole grabbed the computer in line 16 as LC laughed; LC looks back at the computer in line 17-18) laminated their work on the computer as "actually coding."

Both power-laden materials laminate their dialogic and relational activities, in order to co-produce a space that supports their learning as female coders. The manipulation of the tools asserted their position. They moved the joystick and the computer as they would to increase access to their coding experience as well as moved them to share access amongst each other in their developing understanding of a code (lines 7-12). This further makes visible their emerging roles as programmers, authoring their positional identities. In other words, their material and gestural moves laminate the relationship of seeing and performing as the programmers, or "coders." In some ways, they are seeing and being seen as programmers in this moment, even if it is as girls. Their developing abilities highlight the learning space as one co-authored to encourage skill development as well as leadership - both integral to successful careers in engineering.

Seeing and being seen as a valued part of an engineering team is necessary in affirming one's budding identity as an engineer. In an analytic interview, LC confirmed the feeling of being seen and was proud to be recognized as a girl coder who can "actually code," (line 4). She noted further that her view of herself in the field has evolved from the original video recording; she no longer sees Jav's comment as affirming her position as programmer (as she might have in the moment) but instead now notices the larger inauthenticity that being a "girl" engineer and programmer brings. The comment leaves her uncomfortable now.

Describing new insights gained from being in her university STEM program, LC noted the importance of "being a young Afrolatina on the team, since we don't see a lot in the field right now." Her abilities were often underrecognized within her university engineering program since it was generally believed that girl coders who were accepted were only accepted because someone helped them or coded for them. Her time on the robotics team, being seen, acknowledged, and in relational practice was critical to developing her skills and gaining the confidence to envision herself legitimately as an engineer and challenge the future oppressive positionalities she encountered.

Episode 3: Coders Collaborating with Other Code

Episode 3 occurs a few minutes after episode 2, after LC (coauthor) and Nicole moved to a different location – away from the coding robot – to debug their code by researching different code examples on a computer connected to a larger screen. Their task that day was to create the programming relationship with the pneumatic controls. Here they looked at other code examples on the internet that tied buttons on a controller (or joystick) to the air-pressure controlled operations on the robot. When working in the future, this programming connection was how a human player directed the robot to open and close a claw around a game piece and to change gears as it drives.

They worked sitting close together: Nicole had the control of the mouse of the desktop computer, while LC sat in front of the laptop displaying the code they had been testing earlier. As they worked the coach came by a few times to give them a controller and to readjust the screen they were using (see Figure 3).

Caring relationships were centered here and operationalized to further the co-authoring of the positional identities of LC and Nicole. Once again the two young coders worked collaboratively to create a relational space sustained through acts of care for each other and from other members of the team. In this episode we foreground acts of care initiated by the coach to support LC and Nicole in their coding work and also explore how they positioned themselves as coders within their team and within a larger community of coders in robotics competitions.

As they busily searched for example code on the large screen, Mr. Merkur, the coach, overheard as he passed by that they might need a controller. Despite the fact that this request was not made directly to him, he went in search of it and, once found, brought it to them. The playful exchange that followed built on the shared understanding of familial relationships developed within the team that LC, Nicole and other members have talked about explicitly in multiple interviews.

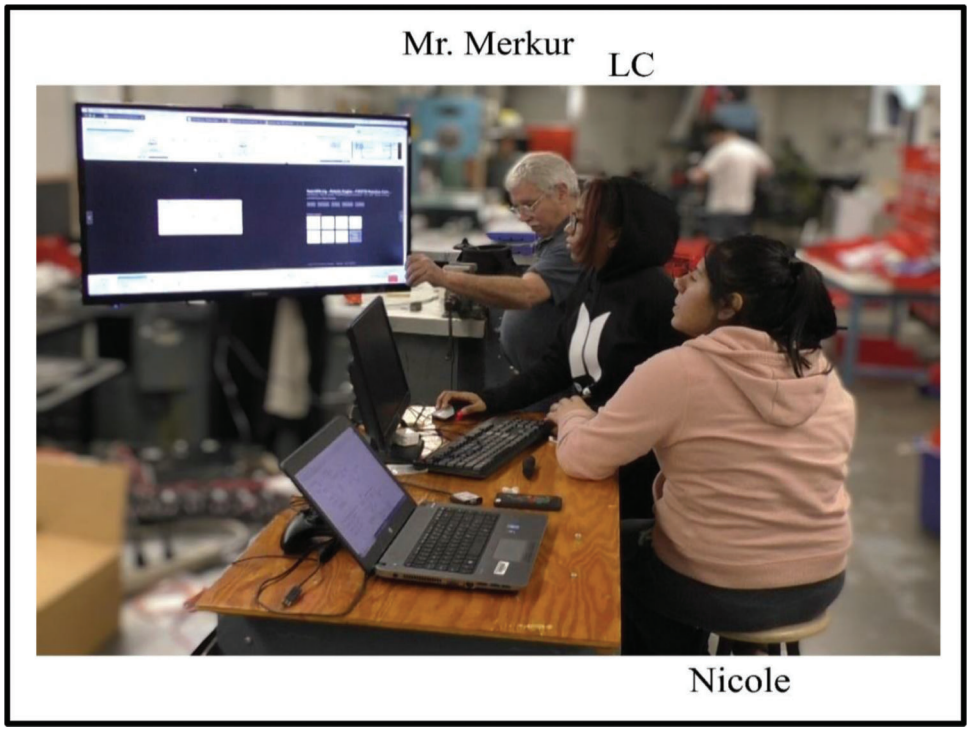

Figure 3. Mr. Merkur adjusts the screen as LC and Nicole look over example code.

1. Mr. Merkur: ((*comes over to table*)) Here ladies, merry Christmas. ((*drops Xbox controller on the table*))
2. Nicole: Y[ay::::::::::::::::::::::::::::
3. Mr. Merkur: [let me clean up this mess ((*grabs items off table*))
4. LC: I love you Ford.
5. Mr. Merkur: I love you too. ((*grabs two more items off the table*)) ((*offers one item in his hand towards LC*)) wanna take that

The tone of their voices was soft and calm, even in the enthusiastic response offered by Nicole [line 2]. The coach's intervention was not perceived as an interruption. Nicole and LC's gaze shifted from the screen to the controller. LC shifted her body slightly to make room on the table for the coach to place the "present." However, LC did not turn to face Mr. Merkur, almost keeping her back turned towards him while the intimate soft spoken but casual "I love you" [lines 4-5] exchange took place. There was no pause and the action continued as the coach tidied up the cluttered space in which LC and Nicole kept working.

This brief conversation, laminated with the gestures of dropping off the controller and grabbing items off their table, builds on a shared understanding of family-like relationships. Mr. Merkur initiated the talk, framing the Xbox controller as a Christmas present [line 1]. This suggestion was picked up as a substrate to build the following turns in talk. Nicole's playful reaction and LC's loving remark [lines 3 & 4], reminiscent of family interactions, laminated the coach's decluttering as part of the caring relationships sedimented in their participation on Turing Robotics.

The coach's intervention supported and reinforced LC and Nicole's opportunities to focus on their coding work. A similar act of care happened a few minutes later, when LC decided to stand up to get closer to the large screen and to be better able to read and point at the display. As Mr. Merkur oversaw the scene, again passing by, he stopped and intervened, even if unrequested and possibly unnecessary, to adjust the screen by bringing it closer to them (depicted in Figure 3). The coach directed his gaze to them, possibly to confirm his adjustment. However, LC and Nicole were too focused on their work and seemed to not notice the coach's intervention. Mr. Merkur then quickly moved on and stepped away.

Later as they worked, LC and Nicole framed their coding practice as done by a collaborative group, a "we" subject. The use of the we/us pronouns was consistent and sedimented in their speech. Nonetheless these pronouns were operationalized in a variety of ways, exclusive and inclusive, to position themselves together in relation to different communities. For example:

11. Nicole: How bout, you see what it says with the button controls the motors. How do **we** do that.
12. LC: See, cause it says what we did before written-- it goes in right to…

[...]

19. Nicole: That's what he made us do.

In the transcript's excerpts above, the use of "we" place LC and Nicole [line 11-12] as the authors of the code that has been and that is being produced. They positioned themselves as coders within the team, but also as a plural coding subject: the contrasting use of the pronouns he/us in line 19, placed them in contrast to Lando, the mentor who often acted as a guide for the coders on the team.

The debugging activity that they carried on brought them to consult a virtual forum where coding members of different robotics teams shared their work. The challenging and antagonistic framing of robotic competitions was paralleled by these supportive virtual communities where coders share their team programming strategies and outcomes to solve specific problems or realize specific actions.

In the next transcript's excerpt, the use of pronouns shifted, revealing the ways these young women thought of and positioned themselves as coders into broader communities.

30. LC: It's gotta be something. (3s) It's CAUSE IT'S TWENTY SS-FOURTEEN RELEASED in twenty seventeen. We need their coding routine.
31. Nicole: Maybe because they used the same exact code.
32. LC: It worked for them. See.
33. Nicole: Where are these people located. Who are they.
34. LC: Ah be like WE NEED your help.
35. Nicole: For real. Your co-- your coders look like they know how to do stuff.
36. LC: Re--rrr wait wa-wa-wait. ((stands up off stool))
37. Nicole: Where are these people.
38. LC: Wait ((moves to the large monitor)) No.
39. Nicole: OH THEY'RE LOCAL CITY:::. [What's your number.
40. LC: [Wait it's] I think we saw them at a competition. Oh uhh wait. ((pointing to monitor)) Button

Looking at a specific piece of code that a team shared on the virtual forum, LC exclaimed "We need their coding routine" [line 30]. This contraposition between the pronouns we/their placed the two young women as members, and in particular as coders, of the robotics team in contrast to coders on a different team. In the first turns in talk from the excerpt the use of they/them/these people, building on the talk substrate offered by LC, set the other teams in an undefined, although connected, location, until Nicole asked about who they were and where they were located. For two turns at talk LC and Nicole transformed the substrate "they," switching to addressing the other team with imaginary direct discourse (we/your). Coders on the other team were recognized as competent and helpful: while LC addressed the coders directly ("we need your help", line 34), Nicole talked to the coders through the team ("your coders look like they know how to do stuff", line 35). This line is particularly relevant when confronted with the ways in which Jav positioned coders in other teams during competitions during the second episode. If Jav's statement situated LC and Nicole as competent "girl" coders against incompetent coders on other teams, in this moment LC and Nicole positioned themselves as members of a broader competent and supportive community of coders. Interestingly, as Nicole enthusiastically recognized the team as being from "[Local City]" [line 39], LC remembered that she and the rest of Turing Robotics ("we", line 40) had met them in the past at a competition. The use of the plural pronoun here, that is maintained as a working substrate throughout the conversation, actually hid the fact that Nicole had not met them yet, as a newer member of the team who had not yet participated in competitions. "We" thus indicated how the membership that is foregrounded is that of the robotics team, which was still inclusive of Nicole as a newer participant.

The complex uses of pronouns are evidence of the nuanced understandings of membership, belonging and relational identities within different communities at different scales. LC's and Nicole's "apprehension of their position in a lived world" (Holland et al., 1998), in particular, as emerging in participating in a robotics team, came to the surface through talk and action, revealing their awareness of their social relationships with other members of close and broad communities, opening up possibilities for reimagining and reinventing present and future identities.

Discussion

In our emerging analysis, the unfolding bonding between LC (coauthor) and Nicole surfaced an intimate relational space produced through acts of care. In this space, that we call a *comfort space*, caring relationships resonate intensely. Material and immaterial resources were deployed to sustain new possibilities and new paths for enacting and apprehending disciplinary roles and relational identities within Turing robotics and broader engineering communities. These resources were assets for their learning and development.

Care produces comfort space for programmer positional identity

We take a relational space to be a socially produced space (Ma & Munter, 2014). That is, we acknowledge the dialectical relationship between participants in activity together and the place where this activity happens. From this perspective of social production, space is a "complexity of interacting social [and material] relations" where efforts to claim certain spaces can include some and exclude others (Massey, 1998, p. 127). As an example, in Ma and Munters' (2014) article, participants at a skatepark consistently engage in *editing* the space to change the activity. This kind of spatial production creates new opportunities for participation and thus for learning. From this perspective, LC and Nicole's ongoing relational work, in relation to their peers and mentors, edits a space that they can claim and be included within.

The comfort space is the physical and social togetherness that emerges as LC and Nicole perform intimate gestures, talk with familiar confidentiality and work and act in close proximity. In this space, comfort is experienced together and fostered for each other through acts of care. This space is not just carved out from the extant space of the shop and sustained through acts of care from within, but also expands outside, creating openings for practicing and (re-)imagining emerging and future identities. It becomes part of their substrates for action in different settings. Here, these two young women demonstrated being willing to learn and grow together (developing as a "we/us"), creating their own path.

A comfort space is thus a space of action and imagination that constitutes an expansion to new possibilities for practicing and reinventing local identities. LC and Nicole's work in practice is consistently collaborative and embedded in their relational space. In episode 1, LC and Nicole worked closely together with others on the wiring of the robot. As all the participants found ways to access the physical space and the tools in order to participate in the wiring work, LC and Nicole carved themselves out a "comfortable" space to be able to practice and safely experience productive failures and moments of success. This comfort space moves beyond the physical material aspects of access to the wiring and expands with the imagination of developing programming identities. By offering the screwdriver to Nicole, for instance, LC forwards a resonance of care that positions Nicole's attempts to complete the task as important to the ongoing action and furthering her as a member of the team. It further develops a collective imagination of Nicole as a programmer and a wirer on the team.

In the first two episodes we also foregrounded how LC and Nicole's comfort space was sustained by recurrent and reciprocal acts of care and affective gestures, such as touching one's arm or hand, and maintaining close physical proximity between them; Nicole and LC offered space to each other, sometimes encouraged their further work with a touch to the back, a high five, or even a close cuddle (see episode 2). In episode 2, following Jav's comment, LC and Nicole looked and smiled at each other and LC hugged into Nicole's shoulder. This particular caring reaction signals a distinct move into LC and Nicole's comfort space as a way to grapple with Jav's comments on girl coders and its local consequences. A comfort space is also where moments of local affirmation and validation of LC and Nicole's competence and role within the team are processed together. These comfort spaces were not simply maintained by Nicole and LC but were taken up and co-developed by other participants. For instance, when Damir stepped back to allow Nicole room to work at the robot or Lando offered that it is alright if she breaks the piece in attempting it, they were engaging in the defining of the comfort space. Additionally, in episode 3 Mr. Merkur, the team coach, further supported this comfort space intervening at its borders and contributing to the creation of a material infrastructure (bringing the controller and shifting the monitor) that allowed Nicole and LC to focus on their work as coders and competent members of the team. This further offers room to imagine themselves as coders in the larger community of robotic competitions. Comfort spaces are thus not just produced through acts of care from within, but also sustained with acts of care from without.

Nicole and LC's positional identities as programmers are dependent on each other's and deeply intertwined with their unfolding relationship. LC's presence as a programmer carved out room for Nicole to author an unfolding positioning as a programmer and Nicole's collaborative and social presence offered opportunities for LC to craft spaces for each of them to push on the historical and normative precedent where young women were not programmers, as LC pointed out in later reflection. The two of them, together, co-author positional identities as the team's programmers through relational negotiations that crafted an insider relationship, a budding friendship and collaboration, and an outward facing relationship with others on the team. Their co-authorship was precipitated by a space of comfort for the two of them to develop their skills as the only coders on a male-dominated team, which furthered a positional identity authorship as budding programmers and engineers. LC's consistent practice of touch, grabbing Nicole's arm when she hears a comment that moves her or leaning into her to see the work they are doing together, sustains and builds the space of comfort the two of them depend upon in order to develop their skills. Accordingly, their positional identities were co-constructed as young Women of Color and carriers of personal autonomy and authorship. Female embodiment and collaboration are pathways to upholding dignity in the male dominated STEM setting (Sengupta-Irving & Vossoughi, 2019).

Functionality of invisibility to later be more visible

In episode 2 and 3, where LC and Nicole worked specifically on the code of the robot, the rest of the activity in the shop continued visibly and audibly around them, almost chaotically from time to time. Analyzing the recording of the cameras, a sometimes-stark contrast emerges between the mechanical work that loudly and dynamically animated the shop and the often more static and soft-spoken coding work that kept Nicole and LC sitting in front of a computer for long chunks of time. Programmers' work on Turing Robotics is very visible at *certain points* of the season, i.e. during competitions or other moments where the program does not work correctly with a completed robot. However, the ongoing day to day work is not as visible as the design and mechanics.

Moreover, we consider the intersection between this perceived invisibility of coding work and the manifestation of what Faulkner (2011) characterizes as the (in)visibility paradox. Faulkner states that women in professional engineering settings are both highly visible as women in the male-dominated space and almost invisible in the role of engineer. For Nicole and LC, there is power in leaning into the invisibility of their particular role, together, to lessen the impacts of gendered notions that they don't belong. At the same time, Lando's explicit recruitment for them, as programmers, to join in part of the loud and more visible mechanical work (episode 1) expanded their comfort space for displaying positional identities as programmers and further legitimized them. This also prepared them to take on the more visible moments as programmers later in the season.

The backstage nature of coding, as sometimes invisible work, may attract those who do not wish to be "onstage" or seen as makers of the robot. In its invisibility, the production of becoming engineers as programmers can be cocooned within the space of comfort without the peering domination of the male engineers surrounding them. The space of comfort allowed the coders to develop their new language in plain sight without the supervision of their male peers. This lack of supervision increased their ability to determine the dynamics of their environment, how they resonate care, as well as how they apply power-laden materials to the benefit of their development. It also allowed them to experience productive failure and confusion without the intrusion of young men or the consequent shame of correction which could have dampened and re-oriented what is cared for.

To co-author positional identities as coders, LC and Nicole created a space of comfort in which they may reimagine the reality of their engineering space and center themselves as knowers. The complexity in such creations to invisibly construct a safer space in which to grow in plain sight of their peers highlights the various capacities they had to have in order to forge their space for success within the engineering world. The invisibility, accordingly, allowed them to determine themselves while revealing their own resilience and creativity in the process. LC was amazed by what she was able to achieve in that space when looking back at the videos of herself.

Conclusion and Implications

Above we analyze LC (coauthor) and Nicole's recorded practice *and* their reflections from discussions afterward, which highlighted how positional identities are a part of complex spatial and temporal relations. As the quote we start the paper with indicates, LC had a much different emerging positional identity when watching her practice two years later. Laminating her previous experiences onto her current experiences in the space and time of her university classes, she provided a nuanced perspective on the problem young Women of Color face as they gain access to disciplinary work in higher education. Her positional identity in relation to being a coder and a young woman was shifted, misrepresented, and even mocked as a narrative more consistent with what Faulker (2007) identifies in the engineering workplace: to be taken as an engineer or programmer requires being inauthentic to other ways one is positioned.

At the time, LC perceived Jav's comments about girls coding as an affirmation, or a recognition of positive production seen. The team was perceived as "family," protecting the relational space the programmers were privileged to create. Yet and still, LC experiences intersectional injustices as an Afro-Latinx woman interested in becoming a computer engineer reflecting how Women of Color experience the loss of dignity (Sengupta-Irving & Vossoughi, 2019) in engineering learning spaces. While the episodes above surface issues of gender specifically, we do not discount how the youth's experiences are also racialized, as young Afro-Latinx and Latinx women. In this way, spatial production is a gendered *and* racial project (McKittrick, 2006). LC's experiences in the university classroom after being on Turing Robotics have the possibility to discourage her, burn her out, and shift her vision of her future. We posit that a more equitable future for engineering education requires an expansive vision of engineering that explicitly includes notions of what, and who, is cared for and the kinds of identities it offers to whom and why. When what is cared for remains unexamined, hierarchical notions of who can be an engineer foster false meritocratic ideals of competition and individual achievement. As mechanisms of oppression continue to operate in racialized and gendered ways (amongst other ways), these notions continue to reproduce the exclusion of youth like LC and Nicole by creating unnecessary challenges in reaching success or

even in receiving recognition or respect for their success. Such exclusion is not only oppressive, but limits future innovation (McGee, 2020).

Every learning space is oriented towards caring for something. Some have been explicitly centering care for community for generations. Black feminist perspectives on pedagogy (hooks, 1994; Ladson-Billings 1995) have centered a care for students, communities, and justice. Ladson-Billings (1995) shares that teachers she modeled culturally relevant pedagogy after – who worked exceptionally well with Black students – had a common thread of care that was "their concern for the implications their work had on their students' lives, the welfare of the community, and unjust social arrangements," rather than "the idiosyncratic caring for individual students," (p. 474). The care for pedagogical implications on developing justice and community is also salient in Paris and Alim's (2014) conceptualization of culturally sustaining pedagogy (see also Ladson-Billings, 2014). LC and Nicole's caring practices develop this with a learner centered experience of care. Engineering learning spaces need to learn from their practice and the traditions of Black Feminists it resonates with. Care is central to the pedagogies of many Black, Latinx, and Indigenous communities which has the possibility to be a resource for engaging with and changing the engineering disciplines. Care is a theoretical construct rooted in feminist perspectives (Hill Collins, 2000) that resists the individualistic "efficiency" logic and the human-nonhuman dichotomies, as LC and Nicole's relational practices exemplify.

Creating places where Women of Color can thrive in becoming engineers requires room to encourage and provide freedom for them to be assertive and be themselves without consequence. These should be environments that resonate care for their development and develop spaces of comfort to combat narratives that often position engineering in whiteness and hegemonic masculinity. This requires a shift in disciplinary and epistemological focus towards a recognition of the importance of caring relations for others, both human and non-human, by structurally valuing care work as knowledge work. Reframing disciplinary ways of knowing and doing to include caring relations as inherent parts of the connective tissue of engineering spaces is a start. Learning from LC, Nicole, Damir, Nick, Lando, and Mr. Merkur, this means explicitly imagining engineers as caring for each other's development and rejecting normal competitive logics.

Youth bring in the ability to create strong bonds and caring relations with the urgency to receive and provide care for their peers and communities. When a learning community collectively asks what is being cared for and explicitly engages youth's caring practices, youth's identities, experiences, cultures, and histories become assets. In this perspective, caring relationships emerge ***with*** disciplinary positional identities. Therefore, furthering educational justice outwards past spaces like Turing Robotics requires positional work from not only historically underrepresented youth in STEM education, but their more (unjustly) privileged peers, mentors, coaches, and teachers. Particularly within highly racialized and gendered communities, institutional spaces, and disciplinary fields, it is essential to craft learning spaces that care for relationships while recognizing histories of injustices. An explicit network of relationships, sustained and supported through emerging and sedimented communal caring practices, generates relational spaces where youth can collaboratively author and imagine disciplinary positional identities for futures that work towards justice. As the co-constructed comfort space LC and Nicole crafted exemplifies, there is a lot to learn from how youth can and do apprehend themselves as competent members of engineering communities, which has important implications for how we organize and structure learning spaces accordingly.

The collaborative production of care for Nicole and LC's developing expertise worked to combat local gendered and racialized narratives about who can be successful. Their ingenuity (and that of their peers) offers us a pathway to reimagining engineering education that rejects traditional gendered and racialized positionings in engineering spaces. Explicitly including an ethic of care moves the field beyond equity as representational politics. It offers, as Vakil (2018) articulates for computer science education, a pathway to reclaim engineering education "as a force for justice," (p. 44) where youth and communities are given room to develop positional identities that transform engineering education and engineering disciplines. This starts with asking what is cared for in disciplinary spaces and engaging in youth's practices of care as both assets for the learning community and as disciplinary practices themselves.

Acknowledgments

Thank you so much to the youth, mentors, and coaches from Turing Robotics who have given us the gift of learning from their practice. Thank you to the NYU IAL community (Jasmine Ma, Karis Jones, Arundhati Velamur, Rishi Krisnamoorthy, Sarah Radke, Molly Kelton, Lilly Ardel and more) and Deborah Silvis who pushed our thinking on this project on many occasions. Thank you to Lee Martin and Kristen B. Wendell, the editors of the special issue, as well as the anonymous reviewers who gave this article important feedback, with care, that made it much better.

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