

Engineering Identity Implications on the Retention of Black Women in the Engineering Industry

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Introduction

The engineering education community has identified an imperative to broaden participation in engineering¹. Some have cited the need to backfill the shortfall due to population changes in the nation². Others have cited the ingenuity inherent in a diversified population that is important to the future success of engineering³. Additionally, others have acknowledged the need for an engineering workforce representative of the U.S. population and that provides access to the economic and social capital an engineering degree provides⁴. Regardless of the motivation, initiatives have been implemented in the K-16 space to attract and retain women, people of color, and at the intersections, women of color in to the STEM fields⁵; however, very little attention has been paid to retaining these individuals in the field beyond their educational pursuits within engineering practice^{6,7}. This study was designed to better understand the experiences of Black women in engineering industry using an identity analytical lens.

Engineering has been identified as one field that enables the U.S. to retain its preeminence in the global market⁸. Even with such pressure to attract and retain engineers into the profession, numbers remain low. Despite studies that boast the benefits of having a diversified engineering workforce, women and minority participation does not reflect the U.S. demographic distribution. The National Science Foundation has identified women and people of color from three racial/ethnic groups – Blacks, Hispanics, and American Indian/Alaska Native - as underrepresented in engineering and science⁹. In this work, we focus on positive implications of role identities in engineering on the retention of five Black women in engineering industry. Their experiences and stories demonstrate the ways in which these Black women have used their strong engineering identity to navigate the engineering workplace. This paper provides evidence of ways that engineering identity mediates other barriers to retention in the workforce for these Black women.

Literature Review

The literature on Black women in engineering industry has focused primarily on attrition. Researchers such as Campbell¹⁰, Bell¹¹, and Rice¹² have explored the experiences of Black women in engineering industry utilizing social cognitive career theory, biculturalism, and ecological model of career development, respectively. Each study aimed to uncover the barriers impeding success and/or the strengths that contributed to their success in their professional careers as engineers. Even though each study explored the construct of identity, it was bounded by gender and racial/ethnic identity, never exploring the production and maintenance of an engineering identity. These social identities are important to understand belonging and retention in engineering, but our focus in this work is on how role-identities of Black women as engineers provide support within the workplace.

Individuals have multiple identities that are shaped by and shape their interactions in the world. Depending on the context, one or more of an individual's multiple identities may be more salient¹³. Traditionally in identity research, identities have been described as role, social (or

group), and person (or individual) identities¹⁴. A role identity is defined as, “the internalized meanings of a role that individuals apply to themselves”¹⁴. A role is any type of position that an individual has within society in relation with others’ roles. An identity as an engineer is a role identity because it embodies a specific character that an individual plays within a social sphere. Social identity is based on an individual’s identification with a social group. Social groups encompass any group in which participation creates an ingroup (with membership) and outgroup (without membership). Access and fit with a particular socially constructed group based on traits like race, gender, ethnicity, etc., is one type of social identity. Person identities involve “seeing oneself as a unique and distinct individual, different from others”¹⁴. A person identity emphasizes the need to gather rich, descriptive accounts for each participant in our identity research.

Social and role identities must align for a sense of belonging and self-worth¹⁵. Role identities as well as social identities can be specific to an individual but also include collective expectations of what it means to hold that particular role or group membership in society¹⁴. The distinction of these identities is primarily analytic and provides clearer ways of understanding how individuals see themselves as well as interact in the world. Alignment of an individual and group identities creates opportunities for security in one’s internal perceptions of self as well as ability to receive recognition, approval, and acceptance from others which verifies an individual’s identities. For Black women in engineering industry, negotiating their overlapping social identities as women of color and the engineering role identity within a White, masculine culture can be difficult.

Other discipline-based education research within STEM more often used a role identity framework to understand how women of color navigate the culture and their own identities within STEM^{16,17}. For example, a study on the success of Black women in science careers with science identity as an analytical lens, forced the community to re-evaluate how these women defined success, how these women defined recognition, and therefore challenged the traditional view of career success as scientists. Taking this approach to understanding Black women’s experiences, our study is poised to push boundaries such as these in the discipline of engineering, filling the gap of understanding the definitions and importance of engineering role identity for Black women in the engineering profession.

The **research questions** for this study are:

1. How do Black women define engineering identity in the workplace?
2. How do Black women reconcile their definition of engineering identity with the stereotypical definition of engineering identity?
3. What coping mechanisms are established through personal agency that foster continued engagement in engineering?

Theoretical Framework

Identity theory has been utilized to better understand students’ choice to pursue fields in the STEM profession¹⁸, why they stay engaged through undergraduate and graduate programs^{19,20}, as well as understanding the complexities of identity in the engineering workplace⁷. In science, identity theory has provided insight in to how minority women have redefined recognition in order to remain engaged and successful in a profession that has not been welcoming,

historically¹⁶. Literature suggests that an overwhelming number of Black women that select engineering as a professional option, begin their training in rigorous engineering undergraduate programs, and persist, despite all of the evidence that points to the significant barriers that they overcome, begin their coveted engineering careers but then abandon the profession²¹. The 0.72% that remain engaged perhaps hold the key to understanding the mechanisms necessary to pursuing a satisfying and lengthy career in engineering. The identity framework has proven to be successful in understanding engagement throughout the engineering learning life cycle, K-16 and the workplace^{22, 23,7}; however, it has been limited to race or gender or engineering. The recommendation is to push the boundaries further, to look at the complexities that exist at the intersection of race, gender, and engineering identities. Science education and engineering education researchers have begun to establish the foundation for this expanded exploration, extending this framework further could provide the basis for beginning to understand how to keep Black women engaged in engineering.

Methods

This qualitative study is a pilot for a larger study currently under way and consists of a forty-five minute interview with five Black women who work in engineering industry: *Sylvia, Andy, Rogue, Leoni, and Natasha* (pseudonyms). These women work in various industry sectors ranging from government contractors to online retailers. They have a combined 53 years of experience with the least experienced woman having six years on the job and the most experienced woman having 18 years. A purposive-snowball sampling was used for this study. Purposive sampling is often used in qualitative research to ensure that participants meet the requirements of the study; for this study that included Black women currently employed in engineering industry²⁴. Snowball sampling utilizes a small number of individuals that meet criteria of the study to invite or refer others that also meet the criteria to participate in the study; this method was used to increase the number of participants²⁴. The sampling began with two known Black women in engineering industry that identified other women they thought would be interested in participating in the study. These sampling methods ensured that all of the participants met the preferred sample requirements and created an opportunity to reach a highly underrepresented population within engineering practice.

A semi-structured interview protocol was used during participant interviews. The interview was designed to elicit information in three major areas with a focus on engineering identity: background, work experience, and identity in engineering. The background section consisted of questions relating to influences, undergraduate experiences, and their definition of an engineer. The work experience section explored their work history, relationships in the workplace, the role race and gender had in their experiences in the workplace, and whether they had ever considered leaving engineering. The final section, identity in engineering probed the participants' reflection on their selves as engineers, their ideas of recognition in the engineering world, and future selves in engineering. All interviews were conducted over the phone, recorded, and transcribed verbatim. Each transcript was redacted and sent back to the participant for member-checking.

Using the operationalization of identity often invoked in science education and engineering education, the interviews were analyzed to understand the ways in which these women spoke about engineering, others as engineers, and themselves as engineers, in order to explore their

definition of engineering identity and how they saw themselves as engineers. Utilizing provisional coding, analysis began with a “start list” of researcher-generated codes based on the identity theoretical framework; the list was subsequently revised, modified, and expanded to include new codes²⁵ through deductive and inductive coding cycles. The initial coding list included: engineering identity, relationships, and recognition. However, it was revised to include: *textbook* definition of engineering identity, *personal* definition of engineering identity, and *know thyself*, as these were constructs that emerged in almost every interview.

Results

Participants in this study moved from the traditional, often exclusionary, conceptions of engineers (e.g., anti-social, tinkerers, poor communicators) and have transformed the definition into something that embodies their whole-selves. They have rejected the notion that they must embrace the normative behaviors and participation often portrayed to them through social norms in the workplace, and have instead constructed mechanisms of inclusion that allow them to be true to themselves – their values, beliefs, and their priorities. Instead of being unhappy conforming to the roles that others ascribed to them, they have found ways to be embraced, be satisfied, and be successful as engineers through forging their own definitions of an engineering role identity.

This section will first explore the traditional definitions of an engineer described by the women in this study, followed by their reinvention of what it means to be an engineer to them, how they talk about their embodiment of these traits, and close with how this “knowing of themselves” has allowed them to reframe their engineering role identities, align their role identities with their social identities, and develop a pathway towards success in engineering.

Textbook. When trying to gain an understanding of how each of the participants defined engineering, they were asked to describe the characteristics a person needed to possess to become an engineer. Each of the participants described a “stereotypical” depiction of an engineer. *Sylvia* used words like “anti-social,” “analytical,” “detail-oriented,” and “excellent problem-solving skills.” She described communication amongst her co-workers as, “[...] very unpleasant,” alluding to the perceived communication challenges amongst engineers. *Andy* also used “analytical” to describe engineers, along with “logical” and “data-oriented.” Meanwhile, *Rogue*, *Leoni*, and *Natasha* focused on the ease with which engineers conquer the math and sciences --“I think an engineer is someone who uses science, math, technology and stuff to solve problems”(Rogue). *Natasha* pointed out the tinkering nature of engineers by describing her colleagues as men that are “[...] at home playing with Raspberry Pi [a small, inexpensive computer, namely used by programming hobbyists] and building Ham radios.” They often spoke of these traits as if they were not traits that they possessed themselves, but they acknowledged them as traits of “true” engineers. “I don’t relish in wanting to tinker with something that’s broke. That’s, I feel, like a trait of engineers that I don’t possess” (*Natasha*).

Personal. When the women described how they saw themselves in their roles as engineers, their definitions of an engineer started to change. As they discussed their journey through undergraduate school and their career their description of what it meant to be an engineer no longer reflected the stereotypes that they described initially. They started to personalize their

definitions to now embody personal traits, and they started to describe engineering as part of their individual and collective identities. *Andy* described engineers as individuals with a “strong work ethic... and high integrity,” “being comfortable around technical information,” and “definitely takes a different kind of thinker to be an engineer.” She also described it as “fun,” likening engineering to being “[...] a private detective.” Others began to tell tales of perseverance and grit; grit is often described as a perseverance of effort that promotes the overcoming of obstacles or challenges that lie within an individual’s path to accomplishment²⁶. *Rogue* used words like “brave” and “tough,” yet “approachable” as characteristics necessary to be an effective engineer. *Leoni* emphasized the importance of being self-motivated when she reflected,

You have to be very self-motivated because there are challenges, there are hard challenges. There are difficult professors, there are difficult courses, [and] there are competitions for jobs. You just have to have drive, you have to be self-motivated and know why you want to do it and be willing to work hard.

Leoni personally tied her identity to problem solving when she said,

I solve problems, and so that's one way I identify myself as an engineer. First, [...] what are the possible ways of solving the problem? I think that I have an understanding of the way a lot of different things work, and how they interact with each other. I have a big picture view, that's one thing about engineering, is having the whole in mind, even as you work on just the part. That's the second way I think I'd identify myself as an engineer. I'm fearless, I feel like I can solve any problem, or even if I can't solve it, I can understand what I don't understand. Even if I can't put the puzzle together, I can understand what it is I'm missing that's preventing me from succeeding.

Natasha also spoke of being “a pretty strong person,” the necessity to “have really thick skin,” and the need to be able to persevere through failures,

It takes a certain personality. Because you really have to have a self-deprecating ... you really got to be willing to get a 20% on a test, and not be affected by it, and then try again. I'm not really concerned with failure. That's a characteristic [you] certainly [...] have to possess in engineering. Because you're not going to ... I don't know many people that went through engineering and never didn't fail a test.

All of these women not only transformed their definition of the engineering identity, they spoke of how they embodied the engineering identity. They are engineers. Engineering is part of who they are. They see everything as engineering. They embrace engineering as part of what makes them whole. *Andy* described engineering as a part of her daily life,

I see engineering daily. What I mean by that, is the type of engineering I studied was very process oriented. And everything that you do from figuring what route you want to take to work, trying to figure out how long it is going to take and all of that...that is a process.

Rogue reflected on a time where she was chosen for a job not traditionally engineering, but was told she was selected for the job because she was an engineer,

I was recognized as an engineer, not because of my technical know-how because I was fresh out of college, I didn't know anything about how we do business [...] but [...] because of how engineers think differently. That's how other people see us, as people who think...who approach problems and situations differently.

Leoni embraced the idea that “once you’re an engineer, you’re always an engineer, no matter what it is you’re doing.”

The participants in this study understood and accepted the stereotypes prevalent in pop-culture with regards to engineering in initial descriptions of what it meant to be an engineer; however, they rejected these as the only type of person that could be successful in their field. They instead, described characteristics that are aligned with the profession of engineering (e.g., good ethics, hard-working) but also that were most aligned with their own perceptions of their selves. They used these reconfigurations of engineering identity to remain engaged in engineering. Another mechanism they used to remain relevant, engaged, and successful was simply “knowing themselves” and using this agency to create an inclusive environment. “Know yourself” was described as a form of self-awareness; this self-awareness was not limited to identity alignment, but instead included strengths, weaknesses, limitations, and gifts. These women were clear on the importance of knowing personal boundaries. If a perceived role-identity did not align with their personal identity they found ways to reconcile the mismatch. For example, some women spoke about their White, male-dominated field and that it at times included pressures to conform to and participate in activities they may not find appealing (e.g., happy hours, hiking, running, golfing) and instead integrated their priorities, beliefs, and gifts into their work.

Know thyself. Three of the five women spoke about the importance of knowing their selves to their career success. This idea of “know thyself” has allowed them to develop pathways towards success in their careers. For instance, Leoni spoke about the importance of relationships to career mobility. She understood that having meaningful and authentic relationships with her co-workers, supervisors, and, in some cases, the CTO (Chief Technology Officer) of the company would either contribute to or hinder her ability to achieve career goals. In order to foster these relationships she engaged in the activities that were most popular at her work site,

Where I was in tech, if you literally did not climb mountains, run marathons, or do triathlons, you wouldn't spend a lot of time with the CTO, and he was a very accessible guy, very friendly, accessible guy. But, I saw more of him on [...] my hiking events, [...], but if you weren't doing that, you wouldn't get a lot of time to just sit down.

She, unfortunately, found that these activities detracted from something that was incredibly important to her, family, “I do run races, and I do triathlons when I feel like, and I definitely hiked mountains there for a year and a half, but that took me away from my family too much.” She instead found a way to integrate her family into her work relationships,

I've created a group to focus on family because it's a company that, the people who grew up in it are just starting to have babies, they don't know anything, and so I organize events. Let's do an Easter egg hunt, let's do this, let's do that, and you can always find people, it grows each year.

She was able to establish authentic relationships with her co-workers, stay engaged in workplace extra-curricular events, while not abandoning her family, “[...] you're encouraged to build family life bonds with your coworkers, so I have people that I can call and ask to sit with my kids, I've watched other people's kids.” This was a way for her to integrate her whole self into work.

Natasha, meanwhile, is a self-proclaimed “megalomaniac.” She knew that in order for her to remain engaged she must be challenged, “I'm the type of person, when you challenge me, you give me something to go for, and I believe that's something that entices me, I'm going to go forward balls to the wall.” Knowing this about herself coupled with her “strong will” and “outspoken” nature, have garnered her opportunities to work on complex problems that have pushed her abilities and earned the respect of her peers,

*[...] I came in worked on a project where I didn't know anything about coding really, and I've learned five languages to get a project done. Being guys that don't really speak and aren't really emotional, they did corner me one day. They were like, 'Hey that's really awesome what you did. That's some real bad a** stuff. Most people wouldn't be able to do that, so we respect you for that.' That meant a lot to me.*

Natasha knew that she was not satisfied in any job where she was not challenged. Because of this knowledge of herself, she actively sought out opportunities to work on complex projects.

Knowing thyself, also encompasses being aware of one's own limitations. *Andy* talked about how she always had to “study and work really hard.” Engineering knowledge and proficiency did not come easy for her and she acknowledged this fact; however, she was very dependent on her “work ethic” and “integrity” to get things done. Her yearning to leave her mark on engineering drove her desire to work hard,

I want to try to leave a legacy of some sort. But I toy with how to make a mark? I would love to have a patent or...you know something to that effect. But again, that's not something you just wake up and do. For some, probably, but not for me. Like I said, I have to work. I have to study really hard. I gotta find something.

The two women that did not speak strongly about their engineering identity were *Sylvia* and *Rogue*. *Rogue* has been employed as an engineer for six years; however, her career has largely been comprised of rotations within her company (e.g., supply chain management, security, quality control), perhaps detracting from her establishing a strong personal engineering identity because she did not see her job title or role as directly related to engineering. *Sylvia*, meanwhile, has been a practicing engineer for 14 years. She largely attributes her retention in engineering to embodying the more traditional definitions of engineers, “I can see that we are all anti-social [...] we're all to ourselves in a clique of nerds.” *Sylvia* may have had less tension between her

personal identity and her role identity as an engineer which required less agency for her to author her engineering role identity.

Engineering identity, like most identity constructs is in part crafted by society and part crafted through agency¹⁴. The women in this study, while aware of society's construction of engineering identity, embody a more fluid definition of engineering identity; one that includes attributes of their personalities that have gotten them through the rigors of an engineering undergraduate program. These women are aware of what they have achieved thus far, "I have a very difficult degree to attain, they are not just handing that out" (*Leoni*), and are leveraging it to go even further.

Discussion

Most of the women in this study described a conflict in their role identity (engineer) and the stereotypical social identity (dominant image of a White, male engineer) in the workplace, which in turn made the conflict between the stereotype and their unique person identity (Black woman engineer) exacerbated. In attempts to reconcile their person identity with the social identity, they often found themselves abandoning their person identity in their stories of their early years in their engineering careers. This kind of compromise often led to dissatisfaction in their career. Either from experience, age, or wisdom they found that they did not have to abandon their person identity in order to align their role identity with the social identity. Instead, three of the five participants of this study managed to personalize their definition of engineering identity to include attributes they have either developed or already possessed that contributed to their persistence through and retention in engineering. These women exhibited powerful agency in re-authoring what it meant to embody the role of the engineer consistent with their social identity and person identity. With the exception of *Natasha*, these women have nine plus years of experience in the workplace. When listening to them describe their work history and associated experiences, they reflect on their engineering identity evolution. They began by describing all of the activities and efforts they had participated in, in an attempt to conform to the engineering stereotype and how this forced transformation only brought them disappointment, confusion, and frustration. When they instead embraced what they knew about themselves in the context of work, they had the freedom to enjoy being themselves as engineers. This has empowered them and they, likewise, take pride in who they are as engineers. This insight provides the impetus to continue to "change the conversation" around engineering – who can/should be an engineer, what engineering is, and how people that do not embody the traditional attributes can find happiness and fulfillment in a career in engineering. These women re-authored the engineering identity to fit them rather than change their identities to fit engineering.

Conclusion

If the engineering education community is really interested in broadening participation we must invest in retaining the Black women that successfully complete their academic training. It is imperative that we arm them with the tools to be successful as professional Black women in a White-male dominated workforce. This includes reminding them that they have more to offer than academic prowess. We should remind them that they can be themselves and be engineers, their identities are not mutually exclusive but instead intertwined and essential to engineering as

a profession. If adopting the normative behaviors of the profession make them uncomfortable or go against their own values and priorities, these women must be empowered to create alternative ways of establishing authentic relationships in the workplace. A recommendation includes investigating the impact of seminars or sessions in women in engineering or minority in engineering programs that aid these women in assessing their strengths, weakness, and gifts empower them enough to carve their niche in engineering, one that does not require abandoning parts of themselves to be successful at doing what they do best, engineer.

Future Work

This work is a first step in identifying important reasons why Black women remain in engineering industry despite challenges associated with climate, culture, and the odds against them. Future work includes expanding the study and focusing on Black women in engineering industry with at least ten years of experiences to better understand the ways in which “knowing thyself” has influenced their desire to remain engaged in engineering. Additionally, we plan to unpack how these women’s multiple, overlapping identities interact with and combat the structures in engineering industry. The hope is that such insight could inform the next generation of Black female engineers, so that they can learn to embrace their identity sooner for a happier, more fulfilling, long career in the engineering profession.

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