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REPOSITIONING RACE, GENDER, AND ROLE IDENTITY FORMATION FOR BLACK WOMEN IN ENGINEERING

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Identity theory has been leveraged to explore interest in STEM fields in the K-12 space with particular focus on race or gender. This position paper recommends expanding this use of identity theory to explore identity at the intersection of race, gender, and role to better understand the experiences of Black women in engineering. This piece provides a foundational review of identity theory and how it has been operationalized in science and engineering to provide insight into career pathways, continued engagement, and success of underrepresented populations in these fields. Broadening the current use of identity theory to reexamine engineering experiences through the lens of a Black woman's perspective could yield new conclusions with implications for engineering diversity.

KEY WORDS: *race, gender, identity, Black women, engineering*

1. INTRODUCTION

The representation of women and minorities in engineering has been a long-standing concern for the U.S. According to the latest national reports, women (15%), persons with disabilities (7%), and three racial and ethnic groups—Blacks (1%), Hispanics (1%), and American Indians (<1%) or Alaska Natives (<1%)—are considered underrepresented in engineering (National Science Foundation, 2015). They constitute disproportionally smaller percentages of engineering degree recipients and of employed engineers than they do of the U.S. population (National Science Foundation, 2015). Although the number of women earning degrees in engineering has increased in the past 20 years, women's participation, in particular, Black women, remains well below that of men at all degree levels and in all fields of engineering (National Science Foundation, 2015). Differences in the representation of these groups are rooted in differences in current and historic participation in science and engineering in higher education and differences in educational attainment and in precollege course taking and achievement.

To address these differences, researchers in science and engineering education have utilized a variety of conceptual frameworks to explain the factors contributing to women's lack of interest, course taking, and/or engagement (Schreuders, Mannon, & Rutherford, 2009; VanLeuvan, 2004) participants' degree aspirations and interest in science, engineering, and mathematics (STEM). Identity theory, in particular, has emerged as a compelling conceptual framework for understanding women's engagement, or lack thereof, in science and engineering education. With

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roots in psychology, identity theory in the context of science and engineering education research encompasses a myriad of views an individual has on their relationship with an academic subject, school, classroom, teacher, and students (Jaeger, Haley, Ampaw, & Levin, 2013; Williams & George-Jackson, 2014). Researchers have investigated the various components of identity, such as structure, agency, recognition, and competing identities to gain insight into why students pursue and persist in science and engineering (Ko, Kachchaf, Hodari, & Ong, 2014; Shanahan, 2009). Science education researchers, for example, have explored relationships, such as gender and learning (Brickhouse, 2001; Brickhouse, Lowery, & Schultz, 2000), race and scientific discourse (Brown, 2004, 2005), and interest and engagement (Carlone, 2003, 2004) with science identity formation. Only recently has identity formation emerged in engineering education research (Capobianco, Diefes-Dux, & Oware, 2006; Capobianco, French, & Diefes-Dux, 2012; Godwin, Potvin, Hazari, & Lock, 2013; Tonso, 2006) their interests and attitudes, and on students conceptions of the engineer and the relation to curriculum development. Thus, it is essential to expand our understanding of students\u2019 conceptions about the engineer phenomenon as the foundation for informing STEM education standards and curriculum.

The research reported here contributes to understanding how student engineers on an engineering campus in the US mid-continent not only talked about the kinds of people recognized as engineers on campus, but also juxtaposes their talk about campus engineer identities with two students' ways of presenting themselves as engineers through engineering project teamwork to argue that campus engineer identities framed on-campus interpretations of actions, and ultimately that identity production was a complicated process through which campus engineer identities (cultural knowledge learned on campus. Results from these studies suggest that representing engineering in ways that encourage students to see themselves as engineers provides the basis for establishing an engineering identity. This identity is not a one-time effort but instead a continual process that can be validated or disrupted by their peers, professors, cultural, and institutional practices. Missing from this line of work is an emphasis on the intersection of race, gender, and engineering identity development in the workplace. This begs the question: to what extent can identity theory, as a conceptual framework, inform the interactions of race, gender, and engineering identity development in the workplace?

The purpose of this theoretical essay is two-fold: 1) to present a synthesis of relevant literature on identity theory in science and engineering education and how identity theory has been used to inform the underrepresentation of women in science and engineering; and 2) to propose a new perspective on the application of identity theory by broadening its tenets to include race, gender, and identity formation in engineering and assert implications for prospective research in the field. The recommendation proposed in this essay is to leverage proven frameworks in order to increase the body of literature associated with underrepresented groups, namely Black women.

First, this study will provide a rationale for this line of research on Black women in engineering. The second section will present a synthesis of relevant literature with emphasis on the integration of identity theory. Then the authors will propose a new viewpoint by re-positioning Black women as central to the discourse on engineering identity development. Lastly, this study will suggest implications of the expansion of this framework for conducting research on minorities and underrepresented women in engineering.

2. SIGNIFICANCE OF BLACK WOMEN IN ENGINEERING

Efforts to broaden participation have generated increased interest in understanding the unique

experiences of women of color independent of each other. Researchers have begun to shift away from trying to understand women or minorities collectively and instead explore, mindful of differences, into experiences based on not just gender, but as ethnic/racial minorities as well. Researchers have begun to recognize that not all women experience bias and stereotyping equally. This conversion of researchers has altered the traditional methods of investigating reasons for low participation of women and minorities in engineering. Inquiries that explore women at the intersection of race and gender have revealed results that may have otherwise been overlooked. Recent studies on Black women in engineering concentrate primarily on one of three populations: 1) students (undergraduate and graduate); 2) faculty; or 3) industry professionals. The following section will describe the research around Black women *students* in engineering, in the engineering *faculty*, in the *workplace*, and summarize the *informal dialog* surrounding these women.

2.1 College/University Student Population

Research on engineering undergraduate and graduate students include studies that investigated factors that contribute to persistence and predictors of academic success including self-efficacy, socialization, and psychological well-being. Lord and colleagues (2009) this study recognizes that women of different ethnic backgrounds warrant disaggregated analysis because they do not necessarily share a common experience in engineering education. Using a longitudinal, comprehensive dataset of more than 79,000 students who matriculated in engineering at nine universities, this research examines the question: How does the persistence of engineering students (measured as enrollment to the eighth semester identified a gap in the literature that persistence had never before been disaggregated by race and gender in engineering. They investigated rates of persistence of students at the intersection of race and gender by disaggregating data and found that Black women matriculate at higher rates than any other racial or ethnic women. In the eighth semester Black women represented 39% of Black engineers; while women in all other racial groups hovered around 20%. This evidence supports the need for increased research into retaining Black women in engineer undergraduate programs. Settles (2006) used an intersectional framework for understanding Black women's racial and gender identities of undergraduate and graduate students in science. The experiences of these women at a Midwestern University indicated lower self-esteem and higher depression than women recruited from other universities. Ellis (2001) explored student socialization of doctoral students in STEM fields to determine if there were differences based on race and gender. Through the use of Beeler's theory of graduate adjustment to academic life and Tinto's model of the stages of doctoral persistence, the findings of this study suggest that Black women had the lowest number of experiences in mentoring and advising. Black women also reported more confrontational relationships with their advisors. They also had the most negative reporting of their home department environment; they reported feeling little, if any, connection with their educational community. Tate and Linn (2005), meanwhile, explored the benefits multiple identities (e.g., academic, social, and intellectual) amongst women of color in engineering undergraduate programs aid in persistence. Their findings reveal the complexities situated at the intersection of their race, gender, and "other" identities. Their different identities in varying contexts had influence on one another. The author provided the example of social identity influencing academic identity – if a student felt uncomfortable in an engineering environment this might hinder them from engaging in peer study groups, therefore impacting their academic success and academic identity. This interaction between multiple iden-

tities had implications for academic success and persistence.

Researchers in the academic space investigating students have begun to unearth the value in exploring the intersection of race and gender. Disaggregating data and directing questions at Black women has provided insight into a population that is interested in engineering (matriculation) but has struggled with persistence (graduation rates) and has not been heard. Their voices provide an opportunity to learn how to better retain Black women in the engineering profession.

2.2 Faculty

The number of African American female tenure-track faculty, according to data from the American Society of Engineering Education, has increased from 2% to 3% in the last decade (Berry, Cox, & Main, 2014). Nelson and Brammer (2010) reported that the number of "[…] Black female professors in the physical sciences and engineering is near zero" (p. 16). They further stated, "[…] numbers this small would not survive the statistical treatment, which would be necessary if they were a sample" (p. 16). When scouring the dataset presented by Nelson and Brammer (only) (2010)for indicators of career success, such as full professorship, with the exception of one Black full professor in astronomy, there are no reported Black full professors in the science or engineering departments. Paltry numbers such as these have prompted qualitative studies that explore factors that influence career trajectory (DeCuir-Gunby, Grant, & Gregory, 2013), hinder faculty promotion (Turner, González, & Wong (Lau), 2011) and career satisfaction, such as: stereotype bias (Jackson, 2004), experiential exploration into culture or climate (Jackson, 2004; Rios & Stewart, 2015; Stanley, 2006; Turner, 2002), and ways in which Black women define success in the engineering academy (Edwards, Green Beverly, & Alexander-Snow, 2011). These examinations of the experiences of Black women in engineering faculty have been guided by critical race theory and critical race feminism to describe the engineering academy from the perspective of Black women.

2.3 Workplace

Campbell (2011) utilized four theoretical frameworks as the basis for better understanding the barriers that African American women encounter in the aerospace industry. These frameworks included social cognitive career theory (SCCT) to investigate how her participants' academic and career interest developed, how their career choices were made, and the implications for their career success. Career mobility theory was used to better understand the participants' career progression (e.g., lateral moves, promotions, etc.). Mass career customization theory was leveraged to better understand the career pathways unique to women. This theory provided context for the variation in career trajectory specific to women. Men may experience the career ladder while women are more likely to use the career lattice (a combination of lateral and upward promotions). Lastly, she delved into the complex interaction between biological, psychological, and sociological aspects of humanity through the exploration of a sociobiological framework. This qualitative exploration into the lived work experiences of these women highlighted barriers to remaining in the aerospace industry, as well as supports that aid in retaining these women in the workplace. Biculturalism was the guiding theory of Bell (1990) one being more powerful than the other, but who does not have the ancestry, belief system, or social skills to be fully a member of the dominant cultural group (Park, 1928; Stonequist, 1937, when exploring the experiences of professional Black women (engineers included) and developed the argument that the key to a bi-

cultural existence is compartmentalization. Unlike assimilation, in which a Black woman's black cultural identity is abandoned, compartmentalization allows a woman to maintain her Black cultural identity. Compartmentalization was described as an effective coping mechanism in the engineering workplace; however, it also created greater separation between work life and home life.

Rice (2011) used the ecological model of career development as the theoretical framework to uncover the barriers and structures of success for nine Black women in engineering industry. This study provided insight into the factors that contributed to or detracted from the women's engineering career attainment, as well as experiences in the workplace. All of the women spoke of the workplace being "[...] unreceptive, hostile, and/or challenging" and they often felt alone (Rice, 2011, p. 153). Rice also identified structures of support that included microsystem support (e.g., self-image, determination, and perseverance) and macrosystem support (e.g., family, friends, minority networks, mentors in the workplace, managerial support, and company structure). None of these women claim to have persisted without the macrosystems they constructed around themselves.

Black women in engineering are beginning to garner attention in the literature and while identity is evident in the ways that these women are described, it is not the leading framework guiding prior research studies. When investigating the broader categorizations of women of color in STEM, the identity framework is more often utilized (Carlone & Johnson, 2007; DeCuir-Gunby et al., 2013). 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. Boundaries such as these have not been pushed in the discipline of engineering, presenting a gap when exploring the experiences of Black women and identity in engineering.

3. IDENTITY THEORY IN SCIENCE AND ENGINEERING EDUCATION

Identity and self-concept are often conflated. Before discussing the construct of identity, it is important to first define these terms and their location in the landscape of educational research before comparing and contrasting these constructs by suggesting a model that illustrates their relationship to one another.

3.1 Self-Concept

Baumeister (2005) defines self-concept as an individual's belief about oneself. Self-concept is derived from several factors: certain personality traits (e.g., friendly or talkative), appearance, personal values and life goals, and one's place or role in life (Baumeister, 2005). Self-concept answers the question, "What kind of person am I?" For example, someone might describe themselves as strong-willed or someone that speaks their mind. According to Bong and Skaalvik (2003), it is the totality of the individual's thoughts and feelings having reference to one's self as an object. Markus and Kunda (1986) describe self-concept as a significant regulator of behavior. subjects responded to a series of self-concept measures. Although the uniqueness and similarity subjects did not differ in the trait terms they used to describe themselves, they did differ systematically in their latency for these judgments, in positivity and negativity of their word associations, and in their judgments of similarity to reference groups. These findings imply that subjects made to feel unique recruited conceptions of themselves as similar to others, whereas subjects

made to feel similar to others recruited conceptions of themselves as unique. The results suggest that very general self-descriptive measures are inadequate for revealing how the individual adjusts and calibrates the self-concept in response to challenges from the social environment (Markus & Kunda, 1986).

3.2 Identity

Identity theory can be divided into two distinct, yet related, directions. One direction, structural symbolic interaction, is focused on the way that external social structures define or influence the self and behaviors (Burke & Stets, 2009), while the second, symbolic interaction, is focused on the "internal dynamics of self-processes and behaviors" (Burke & Stets, 2009, p. 34; Stryker & Burke, 2000, p. 285). Structural symbolic interaction suggests that social structures affect the likelihood that an individual will or will not develop particular kinds of selves, learn particular kinds of motivations, and have particular resources for defining situations they encounter (Burke & Stets, 2009). An individual is bounded by social structures. An example of this is present in science education literature that focuses on the importance of a science community in order to formulate a science identity (Brickhouse & Potter, 2001). The absence of belonging to a science community was often found to erode existing science identity or obstruct the possibility of a science identity from formulating (Brown, 2004).

Symbolic interaction, on the other hand, is more in line with an agency view of identity. When a person has claimed an identity, they act on the basis of that identity, and they attempt to fit their lines of action with others in that community to accomplish their goals (Burke & Stets, 2009). An individual adapts when faced with the boundaries of social structure. An example of this is also prevalent in science education literature in communities of practice research, in cases where students have adapted to become part of the community of practice, because they have claimed a science identity and recognize that they need the discourse, tools, and human capital to flourish in the science community (Brown, 2004). McCall and Simmons (1966), however, viewed the two directions intricately intertwined in a two-way communication, constantly either confirming or disproving the other. The social structures informed the internal process, which projects the behaviors back out to the social structure (as cited in Stryker & Burke, 2000). These fundamental definitions of identity are important to acknowledge and understand when considering the identity framework and aids in situating research in the identity space.

Identity theory posits that people have as many selves or identities as they have groups of people with which they interact (Stryker & Burke, 2000). This multitude of identities can, at times, lead to competition or conflict among the identities. In these cases, the identity that is most salient or strong may overcome a weaker or less salient identity. Networks or communities and environment among other factors could play a role in the salience of an identity (Stryker & Burke, 2000). Research conducted in science education explores this competition of identity. Brickhouse and Potter (2001) studied scientific identity formation of two young women of color who attended an urban vocational high school. They found that one participant's "[…] identity as an urban African American young woman seemed to constrain her social interactions in ways that may have worked against her being successful" (Brickhouse & Potter, 2001, p. 974). The young woman described having a science identity, a computing identity (affinity to computer science), an identity as a girl and, as an African-American. Her identity as an African-American young woman was most prominent, therefore, not allowing her to cross into the computing community which emphasized masculine, White identity. The lack of access to the computing com-

munity detracted from her computing identity and thus made her engagement in the program challenging.

3.3 Self-Concept and Identity

Individuals have as many identities as distinct networks of relationships in which they occupy positions and play roles (Stryker & Burke, 2000). An identity is, "[…] a layering of events of participation and reification by which our experiences and its social interpretation inform each other" (Brickhouse, 2001, p.286). Similar to self-concept, identity is always changing. In comparison, these constructs are similar because they are both self-constructed, are subject to change, and can be influenced by environment and social factors. However, articulating the differences is not trivial. Figure 1 is a graphic illustrating the relationship between identity and self-concept. Self-concept includes elements that might not be part of one's identity (e.g., attitudes, behaviors) (Baumeister, 2005). Additionally, identity may contain elements that are not part of the self-concept (e.g., discourse, competence). Self-concept is while influenced by external forces (e.g., interactions, environment), regulated internally; meanwhile, identity can be ascribed by others as well as self-constructed (Baumeister, 2005). However, there is interplay between self-concept and identity; the attitude about one's self dictates behavior consistent with an identity. If someone believes that they are (for example) an engineering person, they will try to engage in the engineering community, participate in engineering discourse, etc. This interplay is illustrated by the space where identity and self-concept overlap. Research shows that an identity can become salient through involvement in a community; such involvement requires that an individual acquires the tools, discourse, and habits of that community (Lave, 1991). While self-concept and identity are not the same, they are dependent on one another. Self-concept is necessary for the creation of an identity, an individual has to have a positive attitude towards an identity before she/he can begin to embrace, participate, and embody that identity (Stout, Dasgupta, Hunsinger, & McManus, 2011).

Self-concept, therefore, is a person's idea of herself, while identity is a socially governed idea of that person. The self-concept is developed and maintained by the subject herself (though it is influenced by environment, knowledge acquisition, and social interactions), and identity is socially constructed and maintained, imposed on the person or adopted by the person. While identity may be described as self-authored, it is heavily influenced by social structures (Holland, Skinner, Lachicotte, & Cain, 1998)female university students in the toils of romance, a case of "borderline personality disorder," and members of Alcoholics Anonymous, all in the US, and a review of courtly love in mediaeval Europe, with theoretical discussions of ideas they have appropriated mainly from Vygotsky, Bakhtin, and Bourdieu. A recurrent example is "the woman who climbed up the house," a low caste Nepalese woman invited by Holland's colleague to join her on the balcony of a house owned by a higher caste family when the owner's wife was visibly present. Instead of waiting to be accompanied through the kitchen, the woman scaled the outside wall of the house and made her way through a small opening in the railing. Her unusual resolution of conflicting pressures (compliance with a request from non-traditional anthropological visitors, pollution to the kitchen of the house they were temporarily living in. Self-concept is internally (though not without heavy influence from external factors) governed while identity is externally governed. An example, a student might believe they are great at academics (i.e., self-concept); however, their transcripts might not be congruent and therefore, their teacher may not regard them as

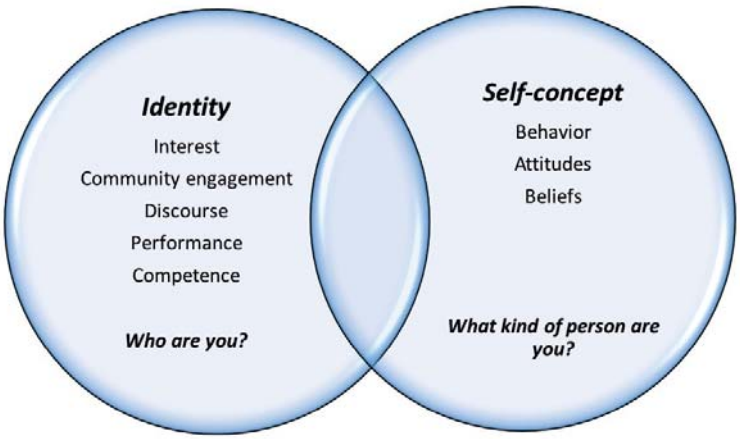

FIG. 1: Conceptualized relationship between self-concept and identity

a "good student" (i.e., identity). In summary, self-concept can be described as the totality of how one perceives her/himself and identity as part of the narrative that one tells about the roles she/he plays.

4. IDENTITY IN SCIENCE EDUCATION

Science education has a long-standing, rich history of exploring identity development, influences, and salience. Science education scholars have developed a robust framework of operationalizing identity that has yielded great strides in understanding participation in science. This section we describe how identity is defined in science education. Next, we explain the important relationship between *science identity* and *science learning*. Lastly, we describe how science education scholars *operationalize* identity in the literature.

Identity refers to one's understanding of one's self in relation to both his or her past and potential future (Brickhouse & Potter, 2001). It refers to ways in which one participates in the world and the ways in which others interpret that participation (Brickhouse & Potter, 2001). As individuals, one has some control over identity, yet, structures and power relations exist that may constrain the kinds of identities available to individuals (Brickhouse & Potter, 2001). Individuals are not always free to be anyone they wish. In cases where formal education is required for membership to some communities, lack of access may limit identity options.

Science education scholars make the case that learning and identity are inextricably linked. They argue that learning is not simply acquiring knowledge, it is also a matter of deciding what kind of person you are and want to be (Brickhouse & Potter, 2001; Kozoll & Osborne, 2004; Shanahan, 2009). Likewise, the more a student participates in activities that link them to a scientific community, the more their identity transforms and subsequently the more they learn (Brickhouse, 2001). Involvement with science becomes part of a progression of more fully becoming one's self, enabling science to become a part of the student's essential worldview and understanding (Kozoll & Osborne, 2004). Identity calls our attention to the individual without

ignoring the context of social structure. It highlights the importance of both individual agency as well as societal structures that constrain individual possibilities (Brickhouse, 2001). This approach is directly in line with McCall and Simmons' (1966) interpretation of identity as the social structures informing the internal process, which in turn, projects the behaviors back out to the social structure (as cited in Stryker & Burke, 2000). According to Brickhouse, Lowery and Schultz (2000), identity is the way in which students are engaged in science and how this is related to who they are, and who they want to be. As a student's identities develop, the necessary knowledge and skills for being a part of the science community are learned. If students are to learn science, they must develop identities compatible with scientific identities (Brickhouse, Lowery, & Schultz, 2000). In the case of multiple identities, there may also be the presence of conflict. This conflict is present when there is a demand of greater degree of loyalty to one identity over the other. It causes the person to prioritize amongst these competing identities (Kozoll & Osborne, 2004). Conflict was a prevalent theme in the study by Carlone (2004), in which reform-based physics was introduced in a course. The expectations of the course did not align with the participant's "good" student identity; the student, therefore, rejected the new delivery of the science content because the science identity was not aligned with the "good" student identity.

4.1 Operationalization of Identity in Science Education

Operationalization is the process by which a researcher defines how a concept is measured, observed, or manipulated within a particular study. This process provides the bridge between theoretically based concepts and the methods used to measure them (Burnette, 2007). Science educators measure identity in their participants in the ways in which they talk about science, act/participate in class, describe being in the science world (classroom) (Brickhouse & Potter, 2001), describe themselves (Brickhouse et al., 2000), or relate to others in the community (Brickhouse & Potter, 2001). These attributes are generally observed through interviews with the participants, their parents, and teachers, as well as observations and journal writing. The language used by the participants either reflected low to high science identity salience. Brickhouse, Lowery, and Schultz (2000) noted statements such as, "[…] I'm really good in science" and, "Science is easy" as examples of participants with a strong science identity (p. 448). Alternatively, Kozoll and Osborne (2004) captured statements like, "Oh yes! I love science, anything that has to do with nature" (p. 172) for strong science identity. In contrast, examples of participants lacking a science identity include statements like, "Well everything that science has involved with it I didn't like" (p. 163) and, "Me, who's not a science person!" (p. 168).

Brown (2005) argued that science discourse is under-recognized as a significant barrier to formulating a science identity and being recognized as having a science identity. He was explicit in his challenge of science as a presumed "[…] apolitical, objective language that is accessible to all" (p. 3). Brown further claimed that discourses are inherently symbolic of intelligence, sophistication, and have political positioning and that science discourse is no exception. In order to formulate a science identity, one must be able to speak the language fluently. This discourse gains students access to the community and provides them the vernacular to be seen as a scientist (Brown, 2005).

A further level of science education has provided a framework for probing participants on how they describe themselves in the world of science, a tool for interpreting participant responses in order to gain insight into how they contextualize their selves in the science world and the theo-

retical basis for explaining the implications of these descriptions on participating in science now and in the future for students. This work in science education provided a proven mechanism for exploring other discipline-related identities, such as engineering identity, which have been less explored to date.

5. IDENTITY IN ENGINEERING EDUCATION

Engineering, much like science education, characterizes identity in the ways that individuals talk about themselves and their perception of how others view them (Du, 2006). Research centered around the development of engineering identity has increased in recent years. Capobianco and colleagues (2015), as well as Yoon and colleagues (2014) have focused on the implications of advancements in elementary education curriculum (that includes engineering components) on engineering identity. Meanwhile, other scholars have explored engineering identity development in undergraduate students through instructor perceptions (Dehing, Jochems, & Baartman, 2013), student experiences (Huff, 2014), the complexities of gender (Ahlqvist, London, & Rosenthal, 2013) and race (Fleming, Smith, Williams, & Bliss, 2013), and epistemology (Danielak, Gupta, & Elby, 2014). These studies have begun to highlight development of engineering identity in students from K-12 to undergraduate and beyond.

There is also a large body of work in the area of communities of practice and their influence on engineering identity development among both men and women (Du, 2006; W. Faulkner, 2009; Hatmaker, 2013; Jorgenson, 2002; Tate & Linn, 2005; Tonso, 2006). Communities of practice are defined as a collection of individuals that have some shared identity (Lave & Wenger, 1991). The members are typically bound by "[…] socially constructed webs of belief, which are essential to understanding what they do" (Brown, Collins, & Duguid, 1989, p. 33). In the study conducted by Faulkner (2011), women engineers' visibility as women and simultaneous invisibility as engineers are explored through the theory of community of practice. The "double paradox" of women needing to "[…] become 'one of the lads,' [while] there are also pressures not to 'lose their femininity'" is identified and described in the study (Faulkner, 2011, p. 286). Du (2006), meanwhile, focused on engineering identity development in communities of practice in undergraduate engineering problem-based learning environments. The results indicated that learning in a community of practice involved participating and maintaining membership to the community; membership defined as possessing cultural knowledge and shared values. Du "[…] argue[d] that the association of these implicit values and expectations with male norms can shape the different ways men and women take in and process knowledge" (Du, 2006, p.39). Hatmaker (2013) explored interpersonal interactions in the engineering workplace. The study determined that "[…] interpersonal interaction place professional identity on the periphery and can overly validate gender identity" (Hatmaker, 2013). The findings provide insight into understanding how the engineering culture and workplace at times marginalizes women. Engineering education has begun to explore identity in both the workplace and in undergraduate engineering programs uncovering the influence communities of practice have on the engineering identity of women and men (Tonso, 2006).

This expansion of identity to include communities of practice pushes the exploration of the identities of Black women in engineering industry beyond themselves. It provides the basis for understanding these women not in isolation but instead in relation to their surroundings. This approach to understanding engineering identity challenges the researcher and participant to consider the influence their relationships at work have on their career satisfaction, career advancement, and likewise their decision to remain or abandon their career in engineering.

6. REPOSITIONING IDENTITY AS A VIABLE THEORETICAL FRAMEWORK FOR STUDYING BLACK WOMEN IN ENGINEERING

Identity is a framework that has been utilized to better understand women's choice to pursue fields in the STEM profession, why they stay engaged through undergraduate and in some cases graduate programs, as well as understanding the complexities of identity in the engineering workplace. Identity in science has provided insight into how minority women have redefined recognition in order to remain engaged and successful in a profession that has historically not been welcoming. This insight can be extended to include engineering. Literature suggests that Black women who find engineering as a professional option worth pursuing begin their training in rigorous engineering undergraduate programs, and those that persist, despite all of the evidence that points to their demise, begin their coveted engineering careers and then abandon the profession. The identity analytical framework has proven to be successful in understanding engagement throughout the engineering learning life cycle, K-16, and the workplace; however, it has been limited to race *or* gender in engineering. This study seeks to push the boundaries further, to look at the complexities that exist at the intersection of race, gender, *and* engineering identities (see Fig. 2).

7. INTERSECTIONALITY

Intersectionality is a powerful analytical framework utilized to examine not only the complexities inherit with being situated at the intersection of race and gender but also the power relations. Intersectionality is rooted in the critical analysis of Crenshaw (1989) of the legal system and its unfair treatment of women of color. The judicial system, at the time, excluded Black women from rights that were protected for women or minorities; however, because these women were both (women and minority) they could not situate themselves in both lawsuits but instead one or other, therefore negating the totality of their experiences and in some cases deeming them unfit to participate in the lawsuit. Crenshaw turned a spotlight on the inequity of the law and this framework has since been extended to numerous disciplines. Given the rich history of intersectionality, recent literature that has been framed as intersectional work, but only examines multiple identities without a critical stance has been severely criticized by many for the lack of alignment with full intersectionality theory (Mitchell, Simmons, & Greyerbiehl, 2014). For this reason, for the purposes of this study such works are not framed as intersectionality theory. Instead it examines the current literature in engineering education that captures an aspect of intersectionality theory, multiple identities.

Engineering education has also begun to explore research with an intersectional lens in order to bring to light the unique experiences of women of color in engineering. Smith and colleauges (2014), explored the connections between communal work goals and feelings of belongingness of Native American engineering students through the disaggregation of women and men. This attention to the differences and similarities provided insight into the intersection of race and gender. Ro and Loya (2015) explored the implications of the intersection of race and gender on learning outcomes of undergraduate students in engineering. Their findings suggest that "the double effect of gender and race" has implications on persistence rates of women of color in the field of engineering. Bruning and colleagues (2015) used intersectionality to demonstrate how gender, race, ethnicity, and socio-economic factors influence perceptions and occupational pursuit of engineering undergraduate school. Ross and Godwin's (2016) preliminary findings on

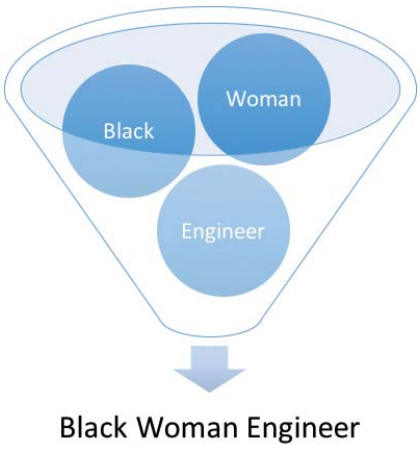

FIG. 2: Intersections of identity - Black woman engineer

a study on Black women in engineering industry suggest that in order to achieve prolonged engagement in engineering their participants had to re-author their personal definitions of being an engineer. This act of re-authoring or redefining what constituted being an engineer enabled them to interject parts of their selves into the definition subsequently changing their perception of an engineering identity. Works such as these expand the use of the identity framework to consider experiences at the intersections.

Social identity theory provides a strong theoretical framework to better understand the choice to pursue engineering as an occupation as well as the decision(s) to remain engaged in engineering. Creating a laser focus on the intersections of race, gender, and role identity (engineer) could be the perspective or viewpoint necessary to better understanding the presence and persistence of Black women in engineering. This proposed viewpoint could aid in answering research questions such as "What is the relationship between women's engineering, racial and gendered identities?" or "What affect do these competing identities have on Black women's retention in the engineering workplace?" Questions such as these allow feminists and other like-minded researchers to probe further into the phenomenon of Black women's lack of representation in engineering; transform human resource policies and practices at universities and engineering firms; mobilize diversity initiatives to be more effective at not only dismantling barriers and establishing supports but also recognizing the capital that these women bring to the engineering workplace.

Research studies designed to explore Black women in engineering industry with an identity framework advance the body of literature on Black women, diversity, engineering, and identity. The framework is complex and expansive; however, it has proven to yield significant strides in understanding interest, persistence, and success in STEM fields. Ong (2005) challenged the traditional exploration of identity to include the intersection of race, gender, and role when exploring the experiences of women of color in physics. Her work highlighted the "invisible sociocultural practices required to become an ordinary member of a scientific culture" (p. 613). Using identity theory to explore the intersections of race, gender, and role identity (engineering) could be a useful mechanism for better understanding the challenges of Black women in a White male dominated field. Unraveling the complexities inherent in the stereotypes ascribed to these women based on race and gender, coupled with the perception of what constitutes being an engineer

could provide insight into why some Black women remain engaged while others leave. This essay provides an overview of how identity has been used in science education, and how this framework could be extended to engineering education research to understand the experiences of Black women across the lifespan of engineering career interest and involvement. Identity theory has proven to be a compelling conceptual framework for understanding women's engagement in science and engineering education. Traditional diversity and inclusion efforts have established a foundation for change; however, exploration into a more intimate understanding of how these women view their role or redefine their role in engineering could be the key to retaining these women in the field of engineering. When research findings, theoretical frameworks, and the basic assumptions of academic disciplines are reexamined through the lens of a Black woman's perspective, new conclusions can be drawn and new directions forged with implications for the lives of both men and women, Black, White, or otherwise.

8. IMPLICATIONS FOR FUTURE RESEARCH

Building on the body of work set forth by the science and engineering education communities researchers should consider leveraging identity to understand continued engagement in engineering of underrepresented minorities. For future research scholars should consider exploring the interplay of identities at the intersection, such as the importance of developing a strong Black woman engineering identity versus a strong engineering identity at the expense of their Black woman identity. Another area of study could be understanding the permeations of identity in a hierarchy or the confluence of identities and the implications on continued engagement. There is a wealth of knowledge to be gained in understanding the implications of racial identity, gender identity, and role identity. Given the historical exclusion of women and minorities from engineering there is implicit bias woven into the fabric of the profession. Understanding the implications of such deep seeded and rich tradition of exclusion of Black women and how they navigate these barriers could unveil some mechanisms for broadening participation. Being able to listen to and learn from the experiences of Black women could provide a depth of understanding with regards to how Black women situate themselves in engineering. It could be that the salience of the confluence of their many identities is an indicator of their interest, persistence, and success in engineering.

Leveraging a proven framework to explore an under researched demographic has the potential to influence the abysmal enrollment and participation of Black women in engineering, from college students, faculty, and the engineering workplace. In-depth exploration into the experiences of Black women and their multiple identities could aid in bridging the gap between research and practice. Understanding of the experiences of Black women that have remained engaged in engineering could not only uncover the challenges but also the capital that these women possess and contribute to the engineering workplace.

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