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THE PIECES OF ME: THE DOUBLE BIND OF RACE AND GENDER IN ENGINEERING

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Women of color (WOC) continue to be underrepresented and underserved in engineering. Current engineering education literature rarely explores the role of the double bind of race and gender in the experiences of WOC. These "hidden figures" are pushed to the margins of engineering based on deeply held negative racial and gender stereotypes. The purpose of this study was to investigate the impact of the intersections of race and gender or the "double bind" on the engineering education of undergraduate female students of color. A quantitative survey measured the engineering identity, ethnic identity, womanist identity, frequency of racial microaggressions, and self-reported mental health (e.g., stress, anxiety, and depression) of female students of color. We found a positive relationship between ethnic identity and engineering identity, as well as relationships between ethnic and womanist identities and self-reported mental health measures. WOC reported high scores on the commitment subscale of the ethnic identity scale, indicating a strong sense of belonging, attachment, and a personal investment

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in an ethnic group, in addition to frequent racial microaggressions. Taken together, WOC who have strong ethnic and womanist identities are susceptible to negative stereotype social cues, but have some protection from the greater, often race-based stressors they experience in engineering. Depression correlated to the frequency of experiencing racial microaggressions. Our results suggest that engineering must do more to improve racial climate, reduce gender and racial microaggressions, and create inclusive educational spaces to ensure the full participation of these students.

KEY WORDS: *women of color, womanist theory, multiple identities, mixed-methods*

1. INTRODUCTION

Traditionally underserved racial/ethnic groups such as African Americans, LatinX, and Native Americans are needed to diversify the next generation of engineers, scientists, and STEM educators. Women of Color (WOC), in particular, represent tremendous untapped human capital that could provide much-needed diversity in perspective that is essential to sustain technological advantages and to promote a positive, inclusive, equitable academic climate. Recently, educators have questioned the STEM community's commitment to increasing the participation of WOC (Alfred et al., 2019). Indeed, national reports of domestic students studying and completing STEM degrees show marginal improvement in broadening participation with a significant lag in engineering (e.g., "African Americans earned 4.8% and 4.2% of master's and doctoral degrees, respectively." American Society for Engineering Education, 2018), despite the known benefits of and need for diversity given the changing demographics of the U.S. population (PCAST, 2012). Therefore, more must be done by the STEM community to attract and retain WOC by enhancing our understanding of how they develop identities (e.g., racial and engineering) within the STEM context (Johnson, 2011).

For students of color, campus climate issues around race, class, and gender shape their higher education learning environment. Research suggests hostile campus climates are associated with students of color changing their majors or leaving STEM fields altogether before graduating (Chang et al., 2014). Such barriers can be more pronounced for WOC who often experience a "double bind" of race and gender marginalization when navigating the STEM culture (Johnson, 2011; Rainey et al., 2018). Therefore, it is important that educators understand experiences of WOC and what is needed to improve students' experiences in order to minimize the gap in key indicators (e.g., retention, achievement, and persistence). We seek to address this STEM need through the guiding research question: "How does the double bind of race and gender impact the experience of women of color in engineering?"

The data reported here are part of a larger, sequential mixed-methods study informed by the womanism theory and multiple identities frameworks. Womanism is an intersectional feminist perspective promoted by female scholars of color that reflects a critical consciousness that multiple forms of inequality coexist simultaneously. We introduce the Womanist Identity Attitude scale (WIAS) (Moradi, 2005; Moradi et al., 2004), which provides a unique way to understand gender and racial identity develop-

ment of WOC along with the intersection of identities. Specifically, the revised version of the WIAS integrated WOC into the survey analysis (Moradi, 2005). Additionally, the multiple identities framework provides a means to produce scholarship that investigates the connection between dimensions of marginalized identity and engineering environments. Social identity models acknowledge that multiple oppressed identities have a multiplicative, not additive, impact (Warner and Shields, 2013). Although scholars have used multiple identities to understand the experiences of students of color in higher education, few engineering education studies apply the model of multiple dimensions of identity (MMDI), particularly for WOC (Blosser, 2020; Yamaguchi and Burge, 2019).

2. THEORETICAL FRAMEWORK

2.1 Womanist Theory

Womanism or womanist theory is a social theoretical perspective grounded in the experiences and history of women of color (WOC), with a historical focus on Black women. Social science scholars argue that gender must be understood in the context of power relations embedded in social identities (Jones, 2009). That is to say, gender must be understood in the context of its intersection with other social identities that are subjected to societal power and privilege. As a result, feminist theory was combined with Black identity development (i.e., Cross's Model; Vandiver et al., 2002) to create the womanist theoretical framework (also referred to as Black feminist theory) that distinguishes the social position and experiences between Black and White women (Boisnier, 2003).

Work by prominent scholar Patricia Hill Collins emphasized the importance of womanist theory in scholarship and often referred to the theory as "Black feminist thought." Collins's 1989 book was the first to integrate the scholarship about and by Black scholars. She asserted Black feminist thought to illustrate the importance of knowledge in empowering oppressed people and portrayed WOC as self-defined, self-reliant individuals that constantly confront oppression based on race, gender, and class (Collins, 1989). Other contributions to womanist theory scholarship include critiques offered by Kelly Brown Douglas, who contended that womanists embrace the notion that identity is also connected to the body and humanity of WOC (Douglas, 2015). Womanist theory was applied in engineering education research when Thomas and colleagues (Thomas et al., 2016) used it to explore the lived experiences of eight Black women in STEM through an analysis of "sistah circles" (Neal-Barnett et al., 2011), characterizing their strategies to navigate the engineering culture starting out as students and eventually as professionals.

Womanist theory is an approach to engage with the diverse ways that Black women have been affected by the interlocking systems of oppression (Collins, 1989) or the "double bind" as defined by Malcom et al. (1976). Previous research suggests Black and White women have dramatically different academic experiences (Boisnier, 2003; O'Brien et al., 2015). Specifically, womanist theory focuses on and values the experiences of Black or African American women and empowers them to define and interpret their social reality based on their values (Taylor, 1998). Black feminists have gradually

recognized that axes of oppression such as racism and sexism are much too intertwined in their own experiences to be overcome with traditional conceptual tools (e.g., antiracism) (Gopaldas, 2013). For example, Collins (2007, 2015) recognizes some commonalities in the lived experience of Black women while also acknowledging the salience and range of expressions within the group resulting from the diversity of class, region, age, and sexual orientation shaping their individual lives. More importantly, the feminist theory roots of womanism are consistent with the approach for the current study, as are the multiple identities of WOC.

2.2 Multiple Identities of Women of Color

Multiple identities is a conceptual framework that provides a way to examine how individuals' demographic (e.g., race, class, gender, ethnicity, and age), cultural, social, and personal identities intersect. This approach emphasizes that a person's experience is not simply an additive sum of individual identities (e.g., African American + female + engineering); instead, all identity dimensions impact an experience simultaneously in ways that are more complex. In addition, the salience of any one dimension of identity can vary greatly by context. The initial conceptual model of multiple dimensions of identity (MMDI) was developed to address multiple traditionally oppressed identity dimensions such as race and gender (Jones and McEwen, 2000). However, the investigation of additional student characteristics led to the reconceptualization of the model to account for the complexity of context, meaning-making, and identity perceptions (Abes et al., 2007). Various studies applied the multiple identities theory to African American college students (Tate and Linn, 2005; Stewart, 2008, 2009). Key in this research is that college students are continually experiencing intersections of their various identities (e.g., racial, gender, professional, etc.) while simultaneously exploring and developing those identities. Furthermore, the relative salience of any dimension of a college student's identities, particularly students of color, varies by context (Tate and Linn, 2005), and multiple identities may be in conflict with each other, leading to negative outcomes (Settles, 2004). For example, some studies on the multiple identities of Black college students found that females tend to separate their social and professional groups (Tate and Linn, 2005). Other study results found that Black college students were able to integrate the multiple dimensions of their identity and grew less reliant on external validation (Stewart, 2008). Multiple identities are thus a useful conceptual framework to explain how female African American engineering students' intersecting identities adjust or adapt during their education.

Some scholars have found MMDI to be a useful framework to understand the educational experiences of WOC. For example, Ross and colleagues encouraged professional WOC to redefine what it means to be an engineer (Ross et al., 2017) and establish authentic relationships in the workplace (Ross and Godwin, 2016) and integrate their engineering identity into their personal identities. Similarly, other researchers found WOC had to use multiple forms of agency to persist in the STEM culture (Ko et al., 2014). Previous research identified systemic challenges for female faculty of color (Turner, 2002) and

used multiple identities as a framework to understand the need and struggle of female faculty of color to integrate their professional identity into their personal, gendered, and cultural identities (Marbley et al., 2011). However, few studies have looked into the multiple identities of female students of color. One example found that positive relationships with faculty and peers supported the engineering identity development of minority students and minority-serving institutions (Fleming et al., 2013). Additionally, Reyes (2011) identified unique challenges for WOC transitioning from community colleges to four-year universities in STEM disciplines. Therefore, this study looks to fill this gap in research by investigating the multiple identities of undergraduate female students of color in engineering at a large research-intensive university. The multiple identities framework is rooted in feminist theory and explicitly situates identity as varied and layered experience within systems of oppression, power, and privilege.

2.3 Research Questions

Leveraging womanist theory and multiple identities, we describe the responses of WOC included in the study during the first phase of the quantitative data collection and analysis in this paper. Specifically, we address the 27 out of 267 respondents that self-identified as WOC (i.e., underrepresented minority [URM] in engineering including African American, LatinX, and Native American) studying engineering. We then qualitatively explored participants' definitions and experiences as WOC in engineering through open-ended responses from the survey. Scholars that study WOC recommend empirical research using a mixed-methods approach to understand the experience of WOC during their STEM education (Alfred et al., 2019). The research questions for the first phase of this mixed-methods study are as follows:

> **Research Question 1:** What are WOCs' self-reported level of identification with engineering, their ethnic identity, and their womanist identity?
>
> **Research Question 2:** What relationships exist among the identity measures that suggest WOC experience the double bind of race and gender in engineering?

3. RESEARCH METHOD

3.1 Positionality Statements

> **Author 1:** My interest and concern about this research topic are relevant to me both personally and professionally. I am a Black, female, same-sex loving engineering professor with strong beliefs around spirituality. I am a first-generation PhD in my family and was raised in a racially and economically segregated large city in the Midwest. My research agenda is to broaden participation in engineering. My previous research investigated the experiences of marginalized groups including students of color and members of the LGBTQ spectrum.

I typically take an intersectional approach to identity in research and I am passionate about giving voice to those often overlooked in the business of educating engineers in the U.S.

Author 2: I am a cisgender, heterosexual, African American woman who was raised by parents who migrated to Chicago from Macon, Mississippi (mother) and Camden, Alabama (father). During my childhood, I spent summers in Camden, Alabama with my grandparents and extended family. These summer experiences influenced my interest in capturing Black cultural wealth that is often hidden. I was raised in Chicago in a Black segregated neighborhood with a strong sense of community. I started studying racial microaggressions in 2007, shortly after arriving at the University of Illinois. This research and other experiences highlight the critical need to understand student experiences on campus and to ensure that all barriers to higher education are eliminated.

Author 3: I am a cisgender, queer, White woman from New England. I am in a straight marriage and am a mother to two daughters. I am an Associate Professor of Anthropology who studies reproductive justice with a focus on understanding the environmental stressors that influence the menstrual cycle. These environmental stressors include not only energetic constraint and immunological challenges, but psychosocial stressors. Much of my recent work has focused on intersecting psychosocial stressors like sexual harassment, racial harassment, and LGBTQ harassment, particularly in academic STEM settings. Much of my service work focuses on providing workshops and trainings to develop skills in PIs so that they lead from principles of inclusion, working from the assumption that leaders must address climate issues that push WOC and other historically underrepresented groups from science.

Author 4: I am an Associate Professor of Biomedical Engineering, and my primary research applies systems biology to address public health needs in women's health, cancers, and cardiovascular disease. Although my primary research departs from the work herein, my lived experience influences my dedication to this research topic. As a first-generation, Nigerian American, cisgender woman, I have encountered racial, ethnic, and gender discrimination, microaggressions, and systemic bias: first in early childhood and at every subsequent stage of my STEM path. Seeing the dubious superfluous barriers that I and others have faced motivates me to create inclusive and diverse spaces through teaching, mentoring, K-16 program development, and cultivating an equitable research lab. Through this research topic, I aim to illuminate the voices of racialized women and to continue shifting STEM culture toward greater inclusivity.

Author 5: I am a cisgender, heterosexual, White woman who has worked on many multidisciplinary teams across engineering and social sciences studying experiences of women and underrepresented minorities in engineering or higher

education. I was raised by working-class parents who worked to support themselves while earning an education when I was a child. I attended a state public university to study chemical engineering on a Pell grant and used federal loans as well as work-study to pay for my schooling. I then pursued a PhD in Chemical Engineering and also pursued a master's certificate in education while funded as an NSF GK-12 fellow. The NSF GK-12 fellowship allowed me to teach 7th grade science two days a week for three years. It was during this time that I taught in several different types of schools including inner city schools, a rural school, and an all-girls magnet STEM program. These different experiences highlighted disparities in education and fueled my desire to study the impact of intersectionality in understanding experiences of underserved populations.

3.2 Methodology

We employed a sequential, mixed-methods study to best answer the research questions of the larger study. The first phase was a quantitative survey followed by an interview to collect qualitative data and allow participants to further explicate their survey answers. The qualitative and quantitative data have equal priority and are connected through data analysis to triangulate the results. The survey was administered in the Fall semester of 2016 and the qualitative interviews were conducted in the Spring semester of 2017. The mixed methodology provides flexibility and is further supported by previous research focusing on women of color (WOC) in STEM (Alfred et al., 2019).

3.3 Participant Selection and Recruitment

Female students enrolled in the College of Engineering attending a large research-intensive institution (e.g., PWI) were recruited for participation in the study. In addition to being enrolled full-time in engineering, the participants were 18 years of age or older. Participants were asked to indicate the race or ethnic group they most identified with as defined by American racial or ethnic categories including Black/African American, LatinX, Native American, Asian, Pacific Islander, White, or Multiracial. However, as we leverage the womanist and multiple identities frameworks, we focused on WOC in engineering for this study, specifically those who identified as African American and LatinX as no Native American women participated. We did not target a vulnerable population, but this paper focuses on the women of color as a subset of the larger sample. To protect participants, we provided mental health support contact information (campus, local, and national) at the end of the survey, created pseudonyms for interview participants, and removed all identifiable information during our cleaning of the transcripts.

Participants were recruited in two ways: (1) the College of Engineering Director of Undergraduate Programs sent a recruitment email to all female students included in the college listserv, and (2) members of the research team also solicited participation of persons underrepresented in engineering through face-to-face recruitment in coordination with faculty advisors for targeted student groups (e.g., Society of Women in Engineer-

ing [SWE] and National Society of Black Engineers [NSBE]). Students were informed about the opportunity to participate without the risk of impacting their grade or standing in the college. Participants were not offered compensation but were encouraged to consider the study as an opportunity to voice their opinion about their engineering education experience as WOC. All participants were notified that they were free to withdraw at any point without penalty. Participants were encouraged to advertise the study to their respective networks (i.e., snowball sampling).

This paper highlights a subset of the total study population and self-identified WOC for a total of 28 participants (N = 10 African American, N = 18 LatinX, and N = 0 Native Americans). Respondents were allowed to identify as multiracial and specify their multiple races. As a result, subgroups existed within the multiple race category and therefore was unable to be included in statistical analysis despite being included in Table 1. The inclusion criteria for the first phase of the data collection included all undergraduate female students currently enrolled in the College of Engineering. In the WOC sample presented here, 45% of participants self-identified as first-generation and 52% indicated their socioeconomic status as middle- to upper-class. The participants were on average 20 years of age and represented 11 different majors within the College of Engineering.

3.4 Measures and Data Collection

Data collection consisted of a quantitative survey managed through Survey Monkey, an online secured data management system. Students accessed the online survey instrument using the link provided in the recruitment email. The survey instrument started by explaining the participation requirements and obtaining consent to participate in the

TABLE 1: Student-reported SES and first-generation status by race/ethnicity

	Self-report status (*n*)					
Race/ethnicity (*n*)	**1st gen**	**Below middle class**	**Lower middle class**	**Middle class**	**Upper middle class**	**Upper class**
American Indian or Alaska Native	0	0	0	0	0	0
Black or African American	2	0	4	5	1	0
Hispanic, LatinX or Spanish origin	10	2	7	4	2	3
Multiple races	1	0	4	14	13	1

Note: Students had the option of marking multiple races or ethnicities, so the totals in the table do not add up to the total number of student responses.

study. The survey instrument included the following published and previously validated measurement scales:

1. **Engineering Identity:** Student identification with engineering measured by the Identification with Academics subscale translated to engineering. Sample items include "Being good at engineering is an important part of who I am" and "It matters to me how I do in engineering school." Each item is rated on a Likert scale from (1) Strongly disagree to (5) Strongly agree (Jones et al., 2010).
2. **Ethnic Identity:** Student level of identification with racial or ethnic identity measured with the Ethnic Identity Scale. Sample items include "I have a strong sense of belonging to my own ethnic group" and "I have often done things that will help me understand my ethnic background better." Each item is rated on a Likert scale from (1) Strongly disagree to (5) Strongly agree (Phinney and Ong, 2007). Two subscales assess the levels of exploring (exploration) and committing to (commitment) an ethnic identity.
3. **Womanist Identity:** Student attitudes reflective of the four stages of womanist identity development measured by the Womanist Identity Attitude scale (WIAS) which consists of four subscales (pre-encounter, encounter, immersion–emersion, internalization) that measure each stage. Sample items from the WIAS include "I would have accomplished more in this life if I had been born a man" and "I am comfortable wherever I am." Each item is rated on a Likert scale from (1) Strongly disagree to (5) Strongly agree (Moradi et al., 2004; Moradi, 2005).
4. **Racial Microaggressions:** Student perceptions of being a member of an undesirable culture or race that is anticipated to perform inadequately. The subscale of the Racial Microaggressions Scale (RMA_SEM) instrument captures students' self-reported frequency of racial microaggressions within the past semester. Sample items include "Others act as if all the people from my race are alike" and "Others suggest that my racial heritage is dysfunctional or undesirable." Each item is rated on a Likert scale from (1) Never to (5) Often/frequently (Torres-Harding et al., 2012).
5. **Patient Health Questionnaire Two-Week:** Student self-reported anxiety and depression measured over a two-week window. The prompt stated, "Over the last two weeks, how often have you been bothered by any of the following." Sample items include "Feeling down, depressed, or hopeless" and "Poor appetite or overeating." Each item is rated on a Likert scale from (0) Not at all to (4) Nearly every day (Kroenke et al., 2001).

Table 2 provides an overview of each scale and subscale including the abbreviations used and the number of items in each subscale. The survey instrument concluded with two open-ended responses to indicate the participant's willingness to be interviewed along with requested demographic information. Demographic information included age, gender, gender identity, major, race, SES, and first-generation student status. The par-

TABLE 2: Abbreviations, scale and subscale names, number of items and Cronbach alpha values

Abbreviation	Scale/subscale names	No. items	Reliability
ENG_IDTY	Identification with Engineering (IE)	5	0.70
EI_EXP	Ethnic Identity subscale exploration	3	0.74
EI_COM	Ethnic Identity subscale commitment	3	0.94
WIAS_PRE	Womanist Identity Attitude Scale (WIAS) subscale PRE-encounter	8	0.68*
WIAS_ENC	Womanist Identity Attitude Scale (WIAS) subscale ENCounter	7	0.31*
WIAS_IMEM	Womanist Identity Attitude Scale (WIAS) subscale Immersion/Emersion	10	0.82
WIAS_INT	Womanist Identity Attitude Scale (WIAS) subscale Internalization	7	0.30*
RMA_SEM	Racial Microaggressions Semester	9	0.93
PHQ_WK	Patient Health Questionnaire 2 weeks	9	0.92

Note: Cronbach alpha values with asterisk (*) fall below the 0.70 threshold (Peterson, 1994; Santos, 1999).

ticipants were asked to provide an email address if they would consider an individual interview as part of the primary data collection for the second phase of the study. The survey completion time typically lasted between 20 and 35 minutes. A more detailed description of the survey instrument is described elsewhere (Cross et al., 2017, 2018).

3.5 Analysis

All statistical analyses for this observational study to detect relationships (Witte, 2010) were performed in SPSS. Subscale validity was evaluated by calculating Cronbach alpha scores. Exploratory factor analysis (EFA) was performed to verify the subscale question sets, as described elsewhere (Cross et al., 2017). Data analysis consisted of classic statistical tests including (1) internal consistency to measure data reliability and compare with published results; (2) Spearman correlations among constructs to measure the strength of relationships between the nonparametric subscales; and (3) analysis of variance (ANOVA) to determine if there is a (statistically) significant difference among the sample means. The general descriptive statistics for each subscale were also calculated for the data set. Summative data maintained the anonymity of the participants while identifying information was strictly used to solicit further participation in the research study.

3.6 Quality

Internal reliability and validity techniques were applied during data collection and analysis to ensure quality. We established face validity by allowing educational research ex-

perts to review the survey items and by conducting a pilot study prior to data collection. Internal reliability is a measurement of research quality and describes the consistency of an instrument's variables every time it is used under the same condition with the same subjects. We calculated Cronbach's alpha value for internal reliability of each survey subscale where Cronbach's alpha describes how well survey items represent the latent variables as shown in Table 2. The acceptable value for social science and educational research is 0.70 (Peterson, 1994; Santos, 1999). Most of the survey subscales met the minimum acceptable criteria of 0.70; however, the WIAS pre-encounter, encounter, and internalization subscales did not meet the criteria (0.62, 0.31, and 0.30, respectively). Although the data, as analyzed, are insightful, the low Cronbach's alpha for the original 50-item WIAS scale suggested a need to employ additional statistical analysis to evaluate the reliability of the subscales for our participant population. We used Hayes' ALPHAMAX procedure (Hayes, 2005) to determine whether a smaller subset of items could be identified that show high internal consistency with this sample. A subset of 23 items (Section 1, questions 1, 5, 7, 9, and 12–14; Section 3, questions 2, 10, and 14; and Section 4, questions 3, 4, 7, 13–16, 18–20, and 23–25) showed good reliability, suggesting a unidimensional factor structure. The Cronbach's alpha values suggest consistency—i.e., the results of the test administered to a group of people positively correlates for that group. That is to say, our results demonstrate that the scales can reasonably measure the study construct for WOC currently studying engineering. We compared our Cronbach's alpha values to our previous work (Cross et al., 2017). As a result, reasonable internal reliability was achieved in the current data set, although some scales were more trustworthy than others. We recognize the small sample size limits the statistical power of our analysis (Witte, 2010) and limits our results to descriptive and relational statistics rather than enabling inferential hypotheses. Overall, we established the quality of the results and research through common educational research methods of reliability.

4. RESULTS

We measured women of color (WOC)s' self-reported level of identification with engineering, their ethnic identity, and their womanist identity. The results are organized based on the analysis procedure and our efforts to answer our research questions. The small sample size (N = 28) was a continuous data set, but not a normal distribution. Therefore, we report frequency distributions for the sample of WOC engineering students. The descriptive statistics presented in Table 3 provide an overall sense of the data set.

The participants reported high levels of identification with engineering and ethnic identity. The subscales of womanist identity showed a distribution of scores or attitudes regarding internal standards of womanhood (Moradi et al., 2004). The WOC in the current study only scored high in the pre-encounter subscale of the WIAS. The participants reported frequent interactions they consider microaggressions. Finally, the participants reported high levels of anxiety and depression based on the provisional diagnosis scoring (Kroenke et al., 2001): the average PHQ score for participants was 19.32, where a score > 20 suggests major depression that should be treated with both medication and

TABLE 3: Survey subscales descriptive statistics (acronyms defined in Table 2)

	N	Min.	Max.	Mean	Std. deviation	Variance	Kurtosis	Std. error
ENGIDTY	28	3.00	5.00	4.5300	0.48000	0.230	–0.020	0.858
EI_COM	28	2.00	5.00	4.3600	0.65400	0.427	5.042	0.858
EI_EXP	28	1.00	5.00	4.2400	1.00600	1.011	2.407	0.858
WIAS_PRE	28	3.64	4.64	4.0455	0.21641	0.047	0.691	0.858
WIAS_ENC	28	2.13	3.75	2.9853	0.38585	0.149	0.191	0.858
WIAS_IMEM	28	1.29	3.00	2.0451	0.43520	0.189	–0.286	0.858
WIAS_INT	28	1.75	3.63	2.6342	0.52174	0.272	–0.882	0.858
RMA_SEM	28	1.00	5.00	3.3800	0.98400	0.967	–0.761	0.858
PHQ_WK*	28	4.00	36.00	19.3200	10.68100	114.078	–1.319	0.858

*The PHQ_WK is a total score; all other reported scores are the mean average for each subscale.

therapy. The elevated scores on the PHQ-9 (average > 15) correspond with a "major depression, moderately severe" provisional diagnosis, the second highest in severity in the PHQ-9 provisional diagnosis scale. The mean average score of the frequency of microaggressions was also fairly high when compared to previous research (Torres-Harding et al., 2012). The Kurtosis statistic, a measure of the outliers relative to the normal distribution of responses, was low and acceptable except for the leptokurtic or peaked distribution as indicated by the high statistic ($K = 5.042 > 3$) observed in the ethnic identity – commitment subscale.

Next, we calculated the Spearman correlations among the subscale measures of identity, the frequency of microaggressions, and self-reported level of anxiety. We calculated the Spearman correlation to evaluate relationships involving ordinal variables (Gravetter and Wallnau, 2013) or specifically between each subscale. In Table 4, the medium-strength correlations (e.g., > 0.4) are bolded and the level of significance is indicated by the number of * to the right of the correlation value. All subscales were comparable to previous studies.

The ethnic identity exploration subscale responses significantly correlated to both microaggressions and self-reported anxiety (i.e., PHQ). The encounter and internalization subscales of the womanist identity measure also showed medium-strength correlations to both microaggressions and self-reported anxiety. The anticipated relationship between the frequency of microaggressions and increased self-reported anxiety was also observed. Interestingly, though, identification with engineering was strong for all participants, but not correlated with any other identity scale measured in the study.

Figure 1 includes a box and whisker plot of the ethnic identity-commitment subscale for first-generation students and continuing-generation students demonstrating the spread of the data in quartiles. Specifically, half of the first-generation students (left box and whisker in Fig. 1) resulted in the highest score of 5 while the other half scored between 4 and 5. The continuing-generation students' (right box and whisker in Fig. 1) scores were more spread ranging from 2 to 5 and included one outlier as indicated by the circle below the box and whisker. From Fig. 1, we conclude that those who identified as first-generation scored higher on commitment to their ethnic identity. Finally, participants shared comments on our open-ended question, "Is there additional information about your engineering education experience that you want to tell us about that is not covered in the survey?" The participant comments are included in the discussion to support our interpretations of the survey results.

5. DISCUSSION

The research presented here illustrates how the double bind of race and gender affects the engineering education of female students of color. Key in this research is that college students are continually experiencing intersections of their various identities (e.g., racial, gender, professional), while simultaneously exploring and developing those identities. Furthermore, our results show that the relative salience of any dimension of a college student's identity, particularly students of color, varies by context and is consistent with

TABLE 4: Spearman correlations of subscales

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. ENG ID	1								
2. EI_COM	–0.087	1							
3. EI_EXP	0.27	0.464*	1						
4. WIAS_PRE	–0.083	–0.16	–0.192	1					
5. WIAS_ENC	–0.236	0.402*	0.162	–0.048	1				
6. WIAS_IMEM	–0.095	0.215	0.194	–0.074	0.253	1			
7. WIAS_INT	–0.178	0.374	0.351	–0.248	0.619**	0.017	1		
8. RMA_2 SEM	–0.049	0.128	0.458*	–0.131	0.416*	–0.174	0.528**	1	
9. PHQ_2WK	–0.097	0.367	0.497**	0.076	0.463*	0.328	0.611**	0.511**	1

*Correlation is significant at the 0.05 level (two-tailed).
**Correlation is significant at the 0.01 level (two-tailed).

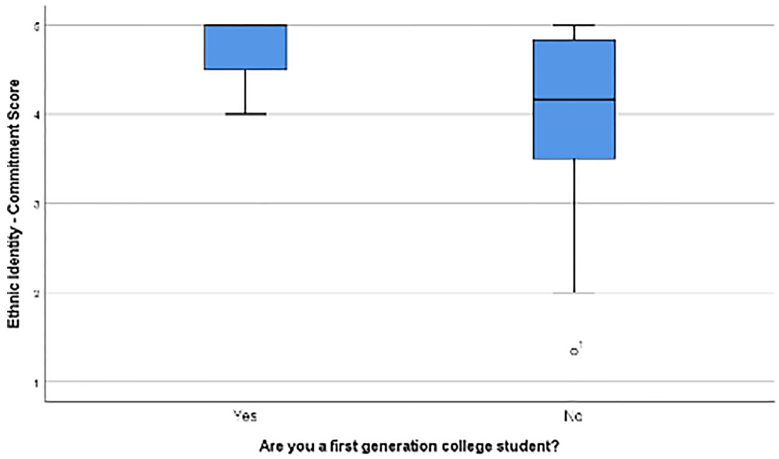

FIG. 1: Box and whisker plot of first-generation status on the ethnic identity – commitment latent variable

previous studies (Tate and Linn, 2005). The results show strong levels of identification with multiple social identities including the students' race and gender but also show high levels of stress and anxiety due to interactions impacted by those identities. The discussion is organized by our research questions and each finding is discussed below in detail within the context of related or previous research.

> **Research Question 1**: What are women of color (WOC)s' self-reported levels of identification with engineering, their ethnic identity, and their womanist identity?

To answer our first research question, we measured multiple dimensions of the participants' identity. Despite typically being isolated, the WOC maintained strong engineering and ethnic identities. This result is important as engineering educators relate engineering identity to several issues including retention (e.g., Pierrakos et al., 2009; Matusovich et al., 2010) and specifically retention of WOC (Ross and Godwin, 2016). Also, the strong ethnic identity is important to note as previous research suggests that Black scholars can perceive an incongruence between their racial and science identities (Brown et al., 2013). To act on our commitment to broaden participation in engineering, we should continue to monitor the engineering and ethnic identity development of WOC within the engineering culture.

Consistent with previous research, the female students of color in this study need support in learning to negotiate between their marginalized and professional identities, specifically how their gender and race/ethnicity intersects with their engineering identities. Keeping in mind that that WOC may experience feminist identity development differently (Boisnier, 2003), the subscales of womanist identity responses in the current study showed a distribution of scores. The scores represent a range of attitudes regarding internal standards of womanhood (Moradi et al., 2004). Specifically, the WOC in

the current study only scored high in the pre-encounter subscale of the WIAS. The pre-encounter subscale is the first stage of womanist identity development where women conform to rigid social norms and tend to deny discrimination against women (Moradi et al., 2004). Therefore, our results suggest that the WOC in our study may have an underdeveloped or diminished sense of womanhood based on masculine social norms in engineering. The result is consistent with previous physics education research that showed that WOC identity development was disrupted by stereotypes becoming salient or activated among their peers (Johnson et al., 2017). Below are a few sample quotes characterizing the negative stereotypes activated by the participant during their engineering education: We use pseudonyms to protect the identity of students.

> ***Alyssa****: I've sat through a whole discussion where I heard people talking about affirmative action and a lawsuit about it. Something along the lines that more qualified people aren't getting into the school because* ***we need to make space for minorities****.*

> ***Maria****: Part of my motivation in life is proving everyone wrong. As a Latina woman in engineering, there have been so many people who have tried to tell me, or have insinuated, that this sort of thing just simply wasn't done. I've been breaking molds my whole life. I was an athlete in high school, too. So, I have always just been this bundle of things-that-stereotypically-don't-go-together. I was a nerdy athlete. I was a Latina who graduated in the top 5% of her class and got a full ride scholarship. People find this hard to believe,* ***and I find that sad****.*

> ***Sierra****: Being from [West Coast], having a Hispanic background, I am used to having people lumping all people who speak Spanish and calling them Mexicans. I am not Mexican, though, and sometimes that relation makes me angry because people also associate the bad things or stereotypes of Mexicans/Hispanics to me. I have noticed that it has increased here in [Midwest] than in [West Coast]. My freshman roommate's mother told me that it was because of my background that I got in with a scholarship while her daughter had to pay full price. Little did she know that her 'full price' was still way below my out of state tuition cost* ***with the scholarship****. As far as being a woman in engineering, there have been times where it's a little off-putting being the only girl in a class, or in a group [co-curricular engineering team]. However, what I have done to get through is think of everything with relation to individuals. There are the few guys out there that give men a bad name, where they are super-condescending and sexist. The best you can do is try to stay away and not have to be in a group with one of them.*

These quotes illustrate how the experiences of WOC activate stereotypes by colleagues simply by being present. Social science scholars suggest that social cues trigger

the psychological condition of stereotype threat where an individual with a stigmatized identity dimension fear they will confirm a negative stereotype about their group in a specific social context (e.g., engineering culture) (Beasley and Fischer, 2012; Deemer et al., 2014; Cadaret et al., 2017). The participants describe being aware of and continually reminded about the perceived intellectual and social inferiority of people of color and women. These participants articulate how their access to higher education and success was predicated upon policy to promote social equity rather than their individual intelligence, hard work, and perseverance. These quotes demonstrate how female students of color in engineering are constantly being required to dispel negative stereotypes based on their group association (e.g., race/ethnicity and gender) and defend their presence within the engineering culture. Thus, the participants expose the impact of the double bind of race and gender on their engineering education by being required to justify their presence and have their intellect questioned, unlike their White male counterparts.

Research Question 2: What relationships exist among the identity measures that suggest WOC experience the double bind of race and gender in engineering?

To answer our second research question, we evaluated the relationships among the measured identity metrics and subscales. Overall, the WOC in the study reported that microaggressions are a common experience for them within the engineering culture. The participants reported frequent interactions they consider microaggressions and correlative relationships were observed among the identity measures. For example, the encounter and internalization subscales of the womanist identity measure also showed medium-strength correlations to both microaggressions and self-reported anxiety. Women in the encounter and internalization subscales are most likely to experience significant shifts in their core sense of self, and as a result may experience more mental health challenges (Carter and Parks, 1996). Additionally, the ethnic identity – exploration subscale responses significantly correlated to both microaggressions and self-reported anxiety (i.e., PHQ). The racial ethnic subscale of exploration is defined as seeking information and experiences relevant to one's ethnicity (e.g., learning cultural practices), but it supports the commitment to one's ethnic racial identity and is critical to the process of ethnic identity formation (Phinney and Ong, 2007). The anticipated relationship between microaggressions frequency and increased self-reported anxiety was also observed in the current study. The participants' elevated levels of anxiety and depression were high when compared to previous research (Torres-Harding et al., 2012). Therefore, the elevated levels of anxiety and depression could be the result of experiencing the combination of race and gender microaggressions. One participant described the microaggressions in the following quote:

***Karin**: The microaggressions are the worst because your only option is to bottle it up. Even when they talk about your hair, you can't be the one to start the fight.*

The WOC in the present study described microaggressions as common everyday experiences. Sue (2010) characterized microaggressions as constant, continual, and

cumulative. The participants reported frequent exposure to microaggressions, and we know that microaggressions lead to negative mental health outcomes. Sue (2010) describes three types of racial microaggressions: microassaults (that are intended to hurt the individual), microinsults (subtle dismissive or demeaning gestures and words), and microinvalidations (minimizing or denying the lived experiences of people of color) (Sue, 2010). Scholars have linked repeated exposure to these toxic assaults, insults, and invalidations to decreased mental and physical well-being (Torres-Harding et al., 2019). Research on 353 Asian American college students found a significant relationship between experiences with racial microaggressions and depressive symptoms (Choi et al., 2017). One participant in the current study spoke about their mental health concerns in the following quote:

> ***Veronica****: It's hard trying to deal with the pressure of school but even more so the pressure of having success due to my race. Furthermore, this leads to problems involving my mental health that are intensified since that topic is* ***never discussed with people of my race****.*

Based on this result we provided participants with information on campus resources for mental health support and met with college administrators to address this significant finding.

5.1 Additional Intersecting Identities

Our supplementary data analysis exposed additional information about the intersecting identities of female students of color in engineering. One-way ANOVAs indicated few significant differences in latent variable means between groups for the independent factors engineering major, SES, and first-generation status. Table A1 (see Appendix for Tables A1–A3) shows the ANOVA results for engineering majors across each latent variable. No significant differences were found across engineering majors. Table A2 shows the ANOVA results between SES groups on each latent variable where no significant differences were found. Finally, Table A3 shows the ANOVA results between first-generation status where one significant difference was found on the ethnic identity – commitment latent variable ($F = 5.718$, $df = 1$, $p = 0.024$). Figure 1 displays the means between first-generation and non-first-generation women in this study. Those who identified as a first-generation student scored higher on this latent variable compared to those who did not (means are 4.72 and 3.87, respectively).

WOC who identified as a first-generation student significantly scored higher than those who did not on the ethnic identity – commitment variable. This result suggests that first-generation students have higher personal investment in their ethnicity groups. First-generation students may come from a family or home that is rich in their ethnic culture and have higher connection with their ethnicities. Research into first-generation WOC can investigate how well-being and ethnic identity influence WOCs' engagement and persistence in engineering. For example, a study found that high-achieving, first-

generation students of color with higher ethnic identity – commitment tended to have lower imposter phenomena with implications on their persistence in college. The non-significant ANOVA results suggest that WOC experience engineering similarly. Future analysis is needed to compare WOC with other women to highlight their unique experiences in engineering.

6. LIMITATIONS

Although the current study has some limitations, they do not diminish the significance of the findings of the study analysis and results. The limited scale and scope of the present study provide direction for the future work and expansion of the study. The results presented here are from a single institution, and we only worked with engineering disciplines. We anticipate that we could learn more by expanding our population to include other STEM disciplines and additional academic contexts. A key limitation of the study is the small number of participants, but this also reiterates our need to do the research as the number of women of color (WOC) studying engineering remains low. Generalizability was not our goal for the study; rather, we aimed to garner as much nuanced information as possible to conjecture innovative approaches to increasing the number of WOC fully participating in engineering. A final limitation is that the data reported here are from a single survey collection with minimal qualitative data. In our future work, we plan to have more data collection points to identify patterns and larger themes that may be pertinent to a wider segment of WOC in engineering and to perform nonparametric analysis. The second phase of the mixed-methods study is forthcoming and will include in-depth semistructured individual interviews to add greater depth and nuance to the survey data presented here.

As the WIAS scale resulted in low internal reliability (Cronbach's alpha), a study is needed to reevaluate this scale for WOC in engineering. The WIAS has been validated in general psychology studies that do not focus on specific contexts (Moradi et al., 2004; Moradi, 2005), and little work has been done in engineering using the WIAS (Cross et al., 2018). More research is needed to understand how women in engineering generally respond to the WIAS because engineering is a traditionally male-dominated culture (Faulkner, 2007; Powell et al., 2009; Smith et al., 2013). Particularly, women in engineering may have a different conceptualization of their womanist identity because of the negative connotations of being a woman in engineering, such as the stereotype that women are bad at math (Jones et al., 2013; Walton et al., 2015; Johnson et al., 2017). As such, future work is necessary to determine how women in engineering respond to the WIAS through exploratory methods (e.g., exploratory factor analysis; Fabrigar et al., 1999). After the underlying patterns are determined for women in engineering on the WIAS, we can then explore womanist identity for WOC.

7. IMPLICATIONS FOR ENGINEERING DIVERSITY

Based on our study results, we identified key implications that will be useful to support diversity efforts in engineering, specifically the ways in which the engineering culture

can be more inclusive of women of color (WOC). Multiple students articulated the daily challenges of being marginalized based on two social identity dimensions, and therefore they must be explicitly taught successful coping and navigation strategies. For example, we can provide WOC with training to advocate for themselves, identify allies, and develop support systems along with healthy coping strategies (e.g., mindfulness and mental health awareness). In other words, we should be actively modeling how female students of color can redefine what it means to be an engineer and support their agency development as a WOC in engineering. We should also collectively call out places in the engineering culture that permit bias and discrimination against WOC to limit their engagement with the field. In addition to educational activities that increase general student engagement, we should also encourage WOC to seek out opportunities to work with their department faculty and leadership to enhance their view of department culture while developing their voice. Similarly, engineering faculty and administrators must acknowledge that WOCs' experiences during their engineering education are unique from those of other groups. Some disciplines, such as computer science, have already begun to acknowledge this phenomenon and address the issue to successfully increase the participation of WOC in the field (Yamaguchi and Burge, 2019). In fact, based on the students' descriptions of regular if not daily microaggressions, we support training faculty to recognize the educational situations that allow microaggressions to occur. Specifically, we suggest faculty training on inclusive pedagogy, multicultural awareness, and Black scholar identity development. Finally, we know that supervisors play a key role in the success of WOC in the engineering profession and we make a parallel argument here for the role of administrators in enhancing the participation and inclusion of WOC in engineering. The academic leadership and administrators should proactively respond to the discriminatory culture of engineering by assigning benchmarks and annual assessment data for diversity metrics. Some universities have already allocated resources to these types of efforts (e.g., https://diversityrecognition.asee.org/). Administrators can also be advocates for female students of color by advertising leadership opportunities and updating student support programs (e.g., counseling, tutoring) with current inclusive practices and concepts.

8. CONCLUSION

This study explores data collected from 28 undergraduate women of color (WOC) studying engineering to identify their perspective on gender and race, or the "double bind," in engineering. The results reveal a complex story of intersecting identities for WOC in engineering. Overall, most students saw engineering as an essential component of their core sense of self as evidenced by the high levels of identification with engineering. We expanded use of the womanist identity attitude scale (WIAS) into the engineering context and related gender and racial identity development to professional identity development, specifically engineering identity. The results of the study suggest the multiplicative effect of being a member of multiple marginalized groups, specifically the double bind. Our participants related both gender and racial microaggressions

that could be contributing to their elevated levels of anxiety. Additionally, our study provides evidence that first-generation status has a relationship with the ethnic identity of WOC in engineering. Therefore, we must use targeted interventions to support female students of color studying engineering as they figure out how to integrate the pieces of themselves and become full participants in engineering.

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APPENDIX A

TABLE A1: ANOVA – Engineering major

		Sum of squares	df	Mean square	F	Sig.
Engineering Identity	Between groups	2.859	10	0.286	1.446	0.242
	Within groups	3.361	17	0.198		
	Total	6.220	27			
Ethnic Identity – Exploration	Between groups	6.169	10	0.617	1.953	0.108
	Within groups	5.370	17	0.316		
	Total	11.540	27			
Ethnic Identity – Commitment	Between groups	10.542	10	1.054	1.069	0.434
	Within groups	16.759	17	0.986		
	Total	27.302	27			
WIAS – Integration	Between groups	0.466	10	0.047	0.991	0.487
	Within groups	0.799	17	0.047		
	Total	1.264	27			
WIAS – Encounter	Between groups	1.403	10	0.140	0.911	0.545
	Within groups	2.617	17	0.154		
	Total	4.020	27			
WIAS – Pre-Encounter	Between groups	1.469	10	0.147	0.685	0.725
	Within groups	3.644	17	0.214		
	Total	5.114	27			
WIAS – Immersion-Emersion	Between groups	2.668	10	0.267	0.969	0.502
	Within groups	4.682	17	0.275		
	Total	7.350	27			
Racial microaggressions	Between groups	11.719	10	1.172	1.383	0.267
	Within groups	14.403	17	0.847		
	Total	26.122	27			
Patient health – two weeks	Between groups	11.726	10	1.173	1.045	0.450
	Within groups	19.075	17	1.122		
	Total	30.801	27			

TABLE A2: ANOVA – SES

		Sum of squares	df	Mean square	F	Sig.
Engineering Identity	Between groups	1.376	4	0.344	1.634	0.200
	Within groups	4.844	23	0.211		
	Total	6.220	27			
Ethnic Identity – Exploration	Between groups	3.050	4	0.763	2.066	0.118
	Within groups	8.489	23	0.369		
	Total	11.540	27			
Ethnic Identity – Commitment	Between groups	2.579	4	0.645	0.600	0.666
	Within groups	24.722	23	1.075		
	Total	27.302	27			
WIAS – Integration	Between groups	0.024	4	0.006	0.113	0.977
	Within groups	1.240	23	0.054		
	Total	1.264	27			
WIAS – Encounter	Between groups	0.659	4	0.165	1.128	0.368
	Within groups	3.360	23	0.146		
	Total	4.020	27			
WIAS – Pre-Encounter	Between groups	1.313	4	0.328	1.986	0.130
	Within groups	3.801	23	0.165		
	Total	5.114	27			
WIAS – Immersion-Emersion	Between groups	1.155	4	0.289	1.072	0.393
	Within groups	6.195	23	0.269		
	Total	7.350	27			
Racial microaggressions	Between groups	1.595	4	0.399	0.374	0.825
	Within groups	24.528	23	1.066		
	Total	26.122	27			
Patient health – two weeks	Between groups	5.213	4	1.303	1.172	0.349
	Within groups	25.588	23	1.113		
	Total	30.801	27			

TABLE A3: ANOVA – First-generation student status

		Sum of squares	df	Mean square	F	Sig.
Engineering Identity	Between groups	0.006	1	0.006	0.026	0.873
	Within groups	6.214	26	0.239		
	Total	6.220	27			
Ethnic Identity – Exploration	Between groups	0.827	1	0.827	2.006	0.169
	Within groups	10.713	26	0.412		
	Total	11.540	27			
Ethnic Identity – Commitment	Between groups	4.922	1	4.922	5.718	0.024
	Within groups	22.380	26	0.861		
	Total	27.302	27			
WIAS – Integration	Between groups	0.005	1	0.005	0.100	0.755
	Within groups	1.260	26	0.048		
	Total	1.264	27			
WIAS – Encounter	Between groups	0.282	1	0.282	1.961	0.173
	Within Groups	3.738	26	0.144		
	Total	4.020	27			
WIAS – Pre-Encounter	Between groups	0.374	1	0.374	2.053	0.164
	Within groups	4.739	26	0.182		
	Total	5.114	27			
WIAS – Immersion-Emersion	Between groups	0.753	1	0.753	2.969	0.097
	Within groups	6.597	26	0.254		
	Total	7.350	27			
Racial microaggressions	Between groups	1.283	1	1.283	1.343	0.257
	Within groups	24.839	26	0.955		
	Total	26.122	27			
Patient health – two weeks	Between groups	3.965	1	3.965	3.842	0.061
	Within groups	26.836	26	1.032		
	Total	30.801	27			