The Double Bind of Race and Gender: A Look into the Experiences of Women of Color in Engineering

Dr. Kelly J. Cross, University of Illinois, Urbana-Champaign

Dr. Cross completed her doctoral program in the Engineering Education department at Virginia Tech in 2015 and worked as a post-doctoral researcher with the Illinois Foundry for Innovation in Engineering Education at the University of Illinois at Urbana-Champaign. At UIUC she has collaborated with multiple teams of engineering faculty on implementing and assessing instructional innovation. Dr. Cross is currently a Research Scientist in the Department of Bioengineering working to redesign the curriculum through the NSF funded Revolutionizing Engineering Departments (RED) grant. She is a member of the ASEE Leadership Virtual Community of Practice that organizes and facilitates Safe Zone Training workshops. Dr. Cross has conducted multiple workshops on managing personal bias in STEM, both online and in-person. Dr. Cross' scholarship investigated student teams in engineering, faculty communities of practice, and the intersectionality of multiple identity dimensions. Her research interests include diversity and inclusion in STEM, intersectionality, teamwork and communication skills, assessment, and identity construction. Her teaching philosophy focuses on student centered approaches such as problem-based learning and culturally relevant pedagogy. Dr. Cross' complimentary professional activities promote inclusive excellence through collaboration.

Dr. Kathryn B.H. Clancy, University of Illinois, Urbana-Champaign

Dr. Kathryn Clancy is an Associate Professor of Anthropology at the University of Illinois. Her research interests are in human reproductive ecology, particularly ovarian and endometrial function, as well as in issues of intersectionality and inclusion in science. Dr. Clancy and her collaborators have examined relationships between inflammation and ovarian function in rural agricultural and urban sedentary environments, and explored ways of non-invasively studying the endometrium in rural contexts. Recently she and her colleagues have empirically demonstrated the continued problem of sexual harassment and assault in the field sciences, and forthcoming results suggest a link between these experiences and the career trajectories of female scientists. She continues to perform research on issues of inclusion, identity, and diversity in science through collaborations with GAMES, the Committee for the Status of Women in Astronomy, and other organizations.

Dr. Ruby Mendenhall, University of Illinois, Urbana-Champaign

Ruby Mendenhall is an Associate Professor at the University of Illinois, Urbana-Champaign. She holds joint faculty appointments in Sociology, African American Studies, Urban and Regional Planning, Social Work and Gender and Women's Studies.. She is currently a faculty member at the Carl R. Woese Institute for Genomic Biology and a faculty affiliate at the Institute for Computing in the Humanities, Arts and Social Sciences, Women and Gender in Global Perspective, and Gender and the Cline Center for Democracy. She is the recipient of the Richard and Margaret Romano Professorial Scholar for outstanding achievements in research and leadership on campus. She is also a Grand Challenge Learning Teaching Fellow in the Health Track. Mendenhall's research focuses on racial microaggressions in higher education. She examines how living in racially segregated neighborhoods with high levels of violence affects Black mothers' mental and physical health using qualitative, quantitative and genomic analysis. She uses big data to recover Black women's lost history using topic modeling and data visualization to examine over 800,000 documents from 1740 to 2014. Mendenhall also does research on the Earned Income Tax Credit (EITC).

Prof. Princess Imoukhuede, University of Illinois Urbana Champaign

Dr. Princess Imoukhuede is an Assistant Professor of Bioengineering at the University of Illinois at Urbana Champaign. She received her S.B. in Chemical Engineering with a minor in Biomedical Engineering from the Massachusetts Institute of Technology, and she received her Ph.D. in Bioengineering from the California Institute of Technology. Prior to joining Illinois, Dr. Imoukhuede completed a postdoctoral

fellowship in Biomedical Engineering at Johns Hopkins University School of Medicine. Her research interests are at the interface of Systems Biology and Angiogenesis with applications to Breast Cancer and Cardiovascular Disease.

Dr. Jennifer R. Amos, University of Illinois, Urbana-Champaign

Dr Amos joined the Bioengineering Department at the University of Illinois in 2009 and is currently a Teaching Associate Professor in Bioengineering and an Adjunct Associate Professor in Educational Psychology. She received her B.S. in Chemical Engineering at Texas Tech and Ph.D. in Chemical Engineering from University of South Carolina. She completed a Fulbright Program at Ecole Centrale de Lille in France to benchmark and help create a new hybrid masters program combining medicine and engineering and also has led multiple curricular initiative in Bioengineering and the College of Engineering on several NSF funded projects.

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Abstract

Traditionally underserved racial/ethnic groups such as African Americans, Latinos/Latinas, 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 a much-needed diversity of perspective essential to sustain technological advantages and to promote a positive academic climate. Recently educators have questioned the STEM community commitment towards increasing the participation of WOC. Indeed, national reports of domestic students studying and completing STEM degrees show marginal improvement in broadening participation with a significant lag in engineering, despite the known benefits of diversity. Therefore, more must be done by the STEM community to attract and retain WOC.

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 leaving STEM fields before graduating. Such barriers can be more pronounced for WOC who often experience a "double bind" of race and gender marginalization when navigating the STEM culture. Therefore, it is important that educators understand experiences of WOC and what is needed to improve students' experiences in order to minimize the performance 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 is part of a larger, sequential mixed-methods study that is informed by the Womanist and intersectionality theoretical frameworks. For the first time, we introduce the Womanist Identity Attitude scale to engineering education research, which provides a unique way to understand gender and racial identity development of WOC along with the intersection of identities. Intersectionality provides a means to produce scholarship that investigates the connection between social identity dimensions and educational conditions. Social identity models that adhere to intersectionality concepts acknowledge that multiple oppressed identities have a multiplicative, not additive, impact. Although scholars have used intersectionality to understand the experiences of students of color in higher education, few engineering education studies apply an intersectionality framework, particularly for WOC.

After a short pilot study, we anticipate the survey results will generate three outcomes. First, the survey results will show what intersecting identities most impact the experience of WOC in engineering, and the extent to which these may operate differently for women of different racial ethnic groups. Second, interview questions and potential themes will be created by grouping results into clusters of intersectionality types or exemplars of intersecting identities. Finally, we will generate strategies to overcome the challenge of the double bind for WOC in engineering by examining the context and scope of intersecting identities emphasized by participants in the survey. Overall, the results presented here will provide the foundation for a larger study that will

lead to a deeper understanding of the challenges WOC face in the engineering culture and expose areas to improve inclusion efforts that target WOC.

Introduction

African Americans, Latinos/Latinas, and Native-Americans, traditionally underserved racial/ethnic groups, will constitute a significant part of the human resources needed for the next generation of engineers, scientists, and STEM educators in the United States. National reports show marginal improvement in broadening the participation of domestic students studying and completing STEM degrees and especially engineering despite benefits of diversity [1-3]. Barriers that prevent more diverse students participating and persisting in STEM include lack of interest and campus climate [4].

Campus climate and issues around race, class, and gender are critical components that shape the learning environment in higher education. Issues around race, class, and gender often make the learning environment hostile and unwelcoming, particularly in science, technology and mathematics or STEM fields. Aspects of the hostility include racial microaggressions which are subtle messages that are insulting or demeaning to people of color [5-7]. Research suggests hostile campus climates are associated with students of color leaving STEM fields before graduating. For instance, African American women make up 25% of African American students entering engineering undergraduate programs but earn only 4% of all engineering degrees [8,9]. In addition, the experiences of marginalized groups are often hidden from university administrators and faculty, creating a knowledge, curriculum and policy gap. It is important that administrators understand experiences of diverse groups and what is needed to improve students' experiences in order to avoid the underdevelopment of their skills and talents (e.g., retention, performance, and contextual competence). This is especially true of women of color who often experience a "double bind" of race and gender when navigating in STEM.

The current study applies an intersectional approach to expose oppressions corresponding to multiple social identities including race, gender, class, and sexual orientation that are unique to WOC [10,11]. Intersectionality provides a means to produce scholarship that investigates the connection between social and educational conditions. Social scientists problematize single social identity factors being used as an analytical dimension and encourage researchers to avoid essentialism, which is the assumption that the social identity of a group is a monolithic, homogenous, and stable entity [12]. Furthermore, social identity models that adhere to intersectionality concepts also acknowledge that multiple oppressed identities have a multiplicative not additive impact. Intersectionality has been used to understand the experiences of students of color in higher education [9], particularly for women of color who experience the "double bind" of race and gender oppression in engineering. The lack of substantial progress in retaining WOC suggests that we do not fully understand the challenges of the double bind that WOC experience in STEM [13]. As a result, the current study will fill this gap by empirically investigating the impact of the intersections of race and gender or the "double bind" on the experiences of WOC within STEM. We seek to address this 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 pilot study generated the following three outcomes. First, the survey results will show what intersecting identities most impact the experience of WOC in engineering. Second, interview question and potential themes will be created by grouping results into clusters of intersectionality types or exemplars of intersecting identities. Finally, our deeper understanding will allow us to generate strategies to overcome the challenges of the double bind for WOC in engineering by examining the context and scope of intersecting identities based on the participant's perspective. Overall, the results presented here will provide the foundation for a larger study that will lead to a deeper understanding of the challenges WOC face in the engineering culture and expose areas to improve inclusion efforts that target WOC.

Methods

A sequential mixed methods study is employed to allow us to best answer the research questions. The first phase is a quantitative survey followed by a follow-up interview to collect qualitative data and allow participants to further explicate their survey answers and their perceptions as a woman of color in engineering. The qualitative and quantitative data will have equal priority and will be connected through data analysis to triangulate the results. The survey was administered in the Fall semester of 2016 and the qualitative interviews will begin in the Spring semester of 2017. The mixed methodology provides flexibility and is further supported with an intersectionality framework and theoretical perspective.

Theoretical Framework

Intersectionality provides the overall framework for the study. While the concept of intersectionality is established, the use of an intersectionality is a novel approach for STEM scholarship, as it is rarely considered in STEM education studies on underrepresented groups. Thus, most studies of underrepresented minorities in STEM ignore the interrelated relationship of race and gender on the lived experiences of women and men of color [9]. Moreover, intersectionality approaches are necessary because the dynamics of gender plays out differently across racial groups in STEM settings when researchers acknowledge the interrelatedness of identities and take a holistic approach [14]. In this study, we intentionally focus on and highlight the intersection of race and gender or the “double bind” of WOC in STEM from an intersectionality approach. Indeed, it is the primary analysis approach, a key component to the research design, and part of the development of the research questions. The current study applies intersectionality as an analysis process with a methodology consistent with fundamental feminist principle through which intersectionality was born. Specifically, we follow an analysis process recommended by intersectionality research experts [15] and situate our study in the larger conversation of intersectionality beyond the two dimension of race and gender.

The intersecting identities of WOC, particularly their gender and race, has been referred to as “double bind” as both identity dimensions are oppositional to the dominant normative white male culture in STEM. Intersectionality is both an analytical process as well as a theoretical framework [15]. More importantly, intersectionality links critical feminist theories of race, class, gender, and sexuality to specific critical methodologies that are epistemologically consistent in ways that were not previously conceived [16]. As a result, intersectionality provides the most flexible and yet foundational tenets to effectively deconstruct the ways in which WOC experience the “double bind” in the context of the STEM culture. Intersectionality that explores

the ways in which gender and race intersect within the experiences of WOC in STEM has rarely been pursued in engineering education research [8,17]. This lack of intersectionality approaches in engineering education research can mask the dismal experiences of WOC with aggregated data where the small number can render this group invisible in the STEM community [8]. **In this paper, we describe the preliminary results of first phase of the quantitative data collection and analysis. The Research Questions for the first phase of this mixed methods study are:**

RQ1: Are there statistical differences between WOC and other female students in the college of engineering in the level of identification with engineering, perception of their ethnic identity, and perception of their womanist identity?

RQ2: Is there statistically significant relationship between the level of identification with engineering, perception of their ethnic identity, and perception of their womanist identity for WOC studying engineering?

Recruitment

Participants who identified as female and currently enrolled in the college of engineering will be eligible to participate. However, the results and analysis in this paper focuses on women of color (WOC) as defined by US racial or ethnic minorities, specifically Black/African American, Latina/o, Native American or Pacific Islander, or multiracial. Participants were recruited in two ways: (a) through engineering professors familiar with the project and (b) through faculty advisors for targeted students groups (e.g. Society of Women in Engineering (SWE) and National Society of Black Engineers (NSBE)) with access to member listservs. Students in the engineering professor's courses were informed about the opportunity to participate without the risk impacting their grade or standing in the class. A community sample was recruited by sending mass e-mails to various student group listservs including, but were not limited to, racial minority professional organizations, and historically Black, Latina/o, or Native American sororities and fraternities. Participants were not offered compensation, but were encouraged to the see the study as an opportunity to voice the opinion about their engineering education experience as women. Participants were encouraged to advertise the study to their respective networks.

Participants

A combination of sampling approaches were used in order to study the sample who identified as a female student currently enrolled in the college of engineering (N = 267). We used a convenient and purposeful sampling approach to reach all the female students in the college of engineering. In the larger population, 87% (WOC =45%) of participants self-identified as first generation and 86% indicated their socioeconomic status as middle to upper class. This paper highlights a subset of the total study population and self-identified women of color for total number of 27 participants. All participants were initially contacted by email and provided a link to the survey containing participation requirements and consent information. The inclusion criteria for the first phase of the data collection included all undergraduate female students currently enrolled in the college engineering. In addition to being enrolled full-time in engineering, the participants were 18 years of age or older. The participants were on average 20 years of age. All the participants were notified that they are free to withdraw at any point without penalty. The participant pool represented 11 different majors within the college of engineering.

The participants' identity and consent were maintained according to IRB requirements. The participant breakdown of major, race, and SES are displayed below in Tables 1 and 2.

Table 1: Participant Breakdown of Race

Black or African American	10
Hispanic American	17
Total	27

Table 2: Participant Breakdown of SES

Upper class	2
Upper middle class	3
Middle class	9
Lower middle class	11
Below middle class	2
Total	27

Data Collection

In the first phase of the study, data collection consisted of a quantitative survey data that was managed through an online secured data management system. Survey Monkey was the data management system used for the study and students could access the online survey instrument with the link provided in the recruitment email. The survey instrument started with explaining consent to participate in the study and the participation requirements. The survey instrument included multiple published and previously validated measurement scales. The measurement scales included the following: 1) identification with engineering [18] to measure engineering identity; ethnic identity scale [19] to measure the level of identification with racial or ethnic identity; 3) Womanist Identity Attitude scale (WIAS) [20] to measure attitudes reflective of the four stages of womanist identity development (i.e., Pre-encounter, Encounter, Immersion–Emersion, Internalization); and 4) the Patients Health questionnaire [21] is a self-report measure of symptoms of anxiety and depression. Each scale include Likert type questions with items rated on a 5-point scale that ranges from strongly disagree (1) to strongly agree (5). 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”. The survey instrument concluded with a two open-ended responses to indicate the participant's willingness to be interviewed and demographic information. Demographics included age, gender, gender identity, major, race, SES, and 1st generation status. The participants 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 20-35 minutes and the research team will report summative data to maintain anonymity of the participants and only use identifying information to solicit further participation in the research study.

Data Analysis

Data analysis consisted of classic statistical testing including 1) the internal consistency to measure data reliability and compare with published results; 2) Pearson correlations among constructs to measure the strength of relationship between the various subscales; and 3) analysis of variance to determine if there is a (statistically) significant difference among the population

means. The statistics were calculated using the SPSS statistical software. The general descriptive statistics for each subscale were also calculated for the data set.

Results and Discussion

The discussion is organized by the research questions addressed in the study. But we begin with general observations of the data and summaries of the descriptive statistics. First, we measured the Cronbach alpha values for each subscale or the internal consistency which is a measure of the extent to which all the variables in your scale are positively related to each other. Below, in Table 3, is the legend to explain all abbreviations for each variable that describes a particular subscale included in the survey instrument.

Table 3: Legend of Scale Abbreviations

Abbreviation	Variable Description
ENGIDTY 1	Engineering identity scale [18]
EI_EXP 2	Ethnic Identity subscale exploration [19]
EI_COM 3	Ethnic Identity subscale commitment [19]
WIAS_PRE 4	Womanist Identity Attitude Scale (WIAS) subscale PRE-encounter [20]
WIAS_ENC 5	Womanist Identity Attitude Scale (WIAS) subscale ENCounter [20]
WIAS_IMEM 6	Womanist Identity Attitude Scale (WIAS) subscale Immersion/Emersion [20]
WIAS_INT 7	Womanist Identity Attitude Scale (WIAS) subscale Internalization [20]
RMA_SEM 8	Racial Microaggressions Scales (2 semesters) [22]
PHQ_WK 9	Patient Health Questionnaire 2 weeks [23]

Cronbach Alpha or Internal Consistency Summary and Comparisons

The internal consistency of most of the survey subscales within the current results are at the acceptable minimum of greater than 0.70 (Peterson, 1994; Santos, 1999). Additionally, all subscale were comparable to previous studies (see table 4). Internal consistency or reliability is a measurement of research quality. Reliability means consistency or the degree to which a research instrument measures a given variable consistently every time it is used under the same condition with the same subjects. The internal consistency values were around 0.70 which is the goal for social science and education research. As a result, reasonable reliability was achieved in the current data set, although some scales were more trustworthy than others. Also, the internal consistency values were calculated for each individual sub-scale to be consistent with procedures to ensure the quality of survey data. The Cronbach alpha values suggest consistency or the results of the administered instrument to a group of people on one occasion correlate very positively. That is to say, our results demonstrate that the scales can reasonably measure the study construct for WOC currently studying engineering. Overall, we have established the quality of the results and research through common educational research methods of reliability.

Table 4: Cronbach Alpha Value Comparison for scales and subscales

Scale/subscale	ITEMS	**Complete**	**WOC Data**	**Published Data**	Author
ENGR IDTY 1	5	**0.70**	**0.62**	0.84	Jones
EI_EXP 2	3	**0.82**	**0.71**	0.83	Phinney
EI_COM 3	3	**0.75**	**0.93**	0.89	Phinney
RMA_SEM 8	9	**0.86**	**0.92**	0.88	Nadel
PHQ_2WK 9	10	**0.90**	**0.93**	0.89	Kroenke

Note: Ethnic Identity has two subscales: EXP = exploration and COM = commitment

Table 5: Cronbach Alpha Value Comparison for WIAS subscales

	ITEMS	**Complete**	**WOC Data**	H&C(1991)	MORADI	Ossana	Boisnier
PRE_4	8	0.53	**0.62**	0.69	0.44	0.53	0.54
ENC_5	8	0.51	**0.32**	0.50	0.31	0.43	0.26
IMEM_6	16	0.79	**0.82**	0.67	0.76	0.82	0.60
INT_7	11	0.57	**(0.17)**	0.80	0.54	0.77	0.38

Note: WIAS has four subscales: PRE = pre-encounter; ENC = encounter,
IMEM = Immersion–Emersion; and INT = internalization

Second, almost two thirds (62%) of the women in the total sample are neutral to or don't have a strong sense of belonging to their racial or ethnic group. The average PHQ score for participants was 30, where > 20 suggests major depression that should be treated with both medication and therapy. Also, the negative internal consistency value for the internalization subscale of the WIAS for the WOC in the current study indicates a violation of reliability model assumptions and negative average covariance among items. In other words, the items within the internalization subscale may be too highly correlated. Generally, the WOC in the current study reported relatively high scores for all scales and subscales, which support our overall perspective of the students' intersecting identities. A summary of the descriptive statistics are below in Table 6. The women in the current study expressed a high level of identification with engineering as evidenced by the average composite score of 23 out of a possible 25. Also, the WOC in the study scored higher on the exploration subscale than the commitment subscale of the ethnic identity measure. Finally, the participants in the current study reported the highest score for the internalization subscale of all four subscales in the WIAS. That is to say, the internalization scale most influence their womanist identity perceptions.

Table 6: Descriptive Statistics for all Scale and Subscales (N=27)

	Minimum	Maximum	Mean	Std. Deviation
Scale/subscale	Statistic	Statistic	Statistic	Statistic
ENGIDTY 1	17.00	25.00	22.5385	2.43690
EI_EXP 2	2.00	5.00	4.3704	.66238

EI_COM 3	1.33	5.00	4.2469	1.02362
WIAS_PRE 4	10.00	24.00	16.0385	3.34043
WIAS_ENC 5	17.00	30.00	23.7692	2.92995
WIAS_IMEM 6	29.00	58.00	42.3846	8.04028
WIAS_INT 7	40.00	51.00	44.4074	2.37388
RMA_SEM_8	12.00	41.00	30.8846	8.99478
PHQ_WK_9	14.00	46.00	**29.8519**	10.50166

RQ1: Are there statistical differences between WOC and other female students in the college of engineering in the level of identification with engineering, perception of their ethnic identity, and perception of their womanist identity?

The percent difference in scores for all scales and subscales, displayed in Table 8, indicate two significantly different subscale scores for WOC compared to the general female population in the College of Engineering. The two sub scales of difference are the ethnic identity subscale for commitment. The commitment subscale generally measures attachment to one's racial or ethnic group. Second, a significant difference resulted from the perceptions of racial macroaggressions scale. The respondents were instructed to indicate the frequency in which they experienced a microaggression over the course of the last two semesters. Furthermore, ANOVA tables suggest that certain identity dimension impacted the WOC experience in engineering.

Table 8: Percent Difference for all Scale and Subscales

Scale	Complete (All)	WOC Data	% diff
ENGIDTY 1	22.5	22.5385	**0%**
EI_EXP 2	3.7883	4.2469	**-11%**
EI_COM 3	11.9234	4.3704	**173%**
WIAS_PRE 4	16.4126	16.0385	**2%**
WIAS_ENC 5	23.9623	23.7692	**1%**
WIAS_IMEM 6	40.6174	42.3846	**-4%**
WIAS_INT 7	45.3764	44.4074	**2%**
RMA_SEM 8	22.951	30.8846	**-26%**
PHQ_WK 9	27.1446	29.8519	**-9%**

RQ2: Is there statistically significant relationship between the level of identification with engineering, perception of their ethnic identity, and perception of their womanist identity for WOC studying engineering?

The statistically significant correlations have moderate levels of correlation. Some scales and subscales had a relationship that should be further explored and suggest an intersection of

identities. For example, the commitment subscale of the ethnic identity scale had statistically significant correlation to the WOC engineering identity. Other results include the two ethnic identity subscales correlating to each other and the racial microaggression scale had a strong correlation the PHQ which is used to self-report levels of depression and anxiety. The subscales of WIAS, immersion and encounter, were also correlated. The emersion subscale of the WIAS is related to the "low achieving and undesirable cultural factor" subscale of racial microaggression scale [22] and most significantly related to depression measure (PHQ) [23]. All other subscales relationships were insignificant.

Conclusions

In conclusion, we combined multiple published instruments to create a holistic instrument to investigate intersecting identities that impact the experiences of women of color in engineering. We piloted the instrument to verify face validity and obtain feedback on question wording and order of the various subscales. The survey instrument was distributed to all female students in the college of engineering, but here we report specifically on the sub-sample of WOC. The study analysis produced three conclusions. First, the internal consistency of the subscales and subscale scores in the current data are consistent with other published data. Therefore we can interpret our instrument as reasonably reliable measure of the constructs assessed the survey. Second, we found moderately statistically significant difference between WOC and other female students in the College of Engineering scores on the scales and subscales included in the survey instrument. As a result, we infer inconsistencies within educational experiences between WOC and other female students and WOC may require targeted student support strategies outside what is currently available in most engineering departments at a large research intensive universities. Therefore, as educators, we need to consider how our current teaching practices in engineering, persist the inequity WOC can experience for the duration of their participation in the field. Finally, the WOC in the current study reported higher scores on the commitment subscale of the ethnic identity measure and the racial microaggressions. The relationship between the ethnic identity and the level of engineering identity suggest that these intersecting identities should be monitored. For example, as WOC identify more with their race or their ethnic identity develops over time, does this have a positive or negative impact on the engineering identity or sense of belong. This relationship can have an impact on the retention of WOC in engineering. This conclusion is further supported by the participant' s womanist identity scores that were connected to their self-report depression level and perception of microaggressions. Next, we also observed medium strength relationship between the level of identification with engineering, WIAS scores, and Ethnic Identity for WOC studying engineering. Some of the subscales had a medium strength relationship. Overall, our results suggest that WOC have a unique experience during their engineering education and that their intersecting identities need to be further studied in a comprehensive qualitative study as they can impact retention and participation in engineering.

Study Limitations

As with any study, study limitations define the scope of the study design and interpretation of the results. One limitation in our study is the small sample size. We combined recruiting and sampling methods in the study to reach as many WOC as we could. However, the overall response rate was lower than expected. Also, despite the internal consistency and total scores in the current data is similar to published instrument, some of the Cronbach alpha values were

lower than the target 0.70 as the standard in educational research. Finally, we limit our implications to the study population and additional data analysis will be required to make our results more generalizable.

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