

Persistence of African American Females in Engineering: The Mathematics Identity Factor

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To continue as global science and technological leaders, the United States is motivated to create a diverse, engineering workforce. One way of diversifying the engineering workforce is to address the disparity of women engineers. Although concerted efforts to improve retention rates of women in engineering are ongoing, women have earned only 5.6% of all undergraduate engineering degrees, with only 1% attributed to African American women (NSF, 2015b). African American women are commonly included in racial or gender-focused studies on persistence; however, few studies assess the effect of multiple identities to persistence. This exploratory study examined the relationship of persistence, measured by intent to persist, to multiple identities (social, professional, and racial) of African American female engineering students. Forward regression analyses were conducted and results indicated that the participant's mathematical identities were more salient to them than their racial or gender identities. Also, the values these women placed on being an engineer and belonging to the group were principal aspects of their professional identity. Additionally, negative affect and stereotype threat were found significant predictors of intent to persist.

Keywords: women engineers, persistence, identity, African American engineers

While African American females represent 6.85% of the entire United States general public and 13.7% of the United States female population (U.S Census Bureau, 2018), they comprise only 0.87% of all engineering undergraduate degrees conferred (Yoder, 2017). Although, African American women are enrolled in college at two times the rate of African American men (Slaughter, Tao, & Wilson, 2015), they are awarded approximately one-third of the engineering degrees granted to African American men (Yoder, 2017). According to the National Science Foundation (2017), since 2004, women have consistently earned 18% to 20% of undergraduate engineering degrees, yet African American women have been awarded only 1% of that total. Likewise, despite concerted efforts to increase African American presence in engineering, African American female representation has declined, from 5.4% in 2003 to 3.5% in 2014 (NSF, 2018). In order to understand this regression and under-representation in earning engineering degrees, consideration of African American women's collegiate experience is essential. Because these women possess multiple identities, their experiences may differ from experiences of women and African American men in engineering programs. Research has shown the significance of evaluating African American female experiences from a multiple-identities-framework to gain better understanding of the impact of identity to their persistence in engineering (Tate & Linn, 2005). Thus, gaining an understanding of African American female identities in relation to their lived academic experiences is vital for increasing their representation in engineering.

Literature Review

The United States has focused their efforts in the direction of increasing representation and retention rates of African Americans in engineering programs (National Academies Press,

2011; NSF, 2015a; Obama, 2013; Valla & Williams, 2012). However, African American women, who made up 6.5% of first-year female undergraduate engineering students in 2016, (NSF, 2018) attained less than 1% of all engineering undergraduate degrees granted to women (NSF, 2015b). Several studies (Carlone & Johnson, 2007; McClain, 2014; Steele, 1997) have centered their investigation of the persistence of African American women in engineering upon a single identity (professional, racial, gender, or social), while a limited number of studies evaluated the impact of multiple identities to the persistence of African American female engineers (McKoy, 2019; Rowley & Moore, 2002; Sellers, Chavous, & Cooke, 1998; Tate & Linn, 2005).

An Examination of Identities That Can Impact African American Females College Matriculation

Gee's (2000) theory suggests that individuals have a primary identity encompassing multiple identities connected to a person's race, gender, and ethnicity, in addition to their lifetime experiences (Gee, 2000; Hogg, 1995). This compounded identity is then influenced by an individual's interpretation of these experiences (Cole, 2009; Holvino, 2010; Warner, 2008), which impacts their ability to achieve personal goals (Tate & Linn, 2005). Although not stated directly, the implication of the aforementioned is that African American female students' continuance in engineering-related careers is linked to their multiple identities and academic experiences (McKoy, 2019). While African American women have multiple identities, three of them (gender, race, and social-economic-status), have been historically associated with oppression. Therefore, it is likely that the experiences of African American women within traditionally, male-dominated, engineering programs would be influenced by their identities and lived college experiences. By focusing only on one aspect of identity, either race or gender, researchers overlook the true experiences of African American women in undergraduate engineering programs. This research explores the persistence (as measured by intent to persist) to multiple identities (social, professional, and racial) of African American women in engineering programs at a southeastern Historically Black University (HBU).

African American female undergraduate students have multiple identities shaped by their interpretation of their lived experiences (Cole, 2009; Holvino, 2010; Warner, 2008). These identities have been found to influence African American women's persistence in undergraduate engineering programs (Rowley & Moore, 2002). One controversial issue is that researchers have primarily focused on only one aspect of identity (race, gender), consequently, ignoring and to some extent, disregarding the total experiences of African American women. Thus, it is important to understand how African American female engineering students experience their academic environments and how their identities influence their intent to persist in engineering programs (Berger & Guidroz, 2009; Crenshaw, 1989; Crenshaw, 1991; Fries-Britt et al., 2013; Gasman et al., 2013; Griffin, & Pérez, 2013; McKoy, 2019). This exploratory study focused upon professional, social, and racial/ethnic identities and their influence upon African American females' intent to persist within an undergraduate engineering program at a HBU. The following describes the identities focused upon within this paper.

Professional Identity

Professional identity has been defined as "one's professional self-concept" (Siebert & Siebert, 2005) which encompasses students' understanding of what engineers do along with demonstrating skills and traits consistent with engineering practices (Chachra et al., 2008). An engineering professional identity is determined by an individual's self-assessment of themselves, their roles, and their responsibilities (Loshbaugh & Claar, 2007; Loui, 2005; Tate & Linn, 2005),

as well as their competence within a career field (McIlwee & Robinson, 1992). African American female engineering students typically enroll in undergraduate programs confident and competent in mathematics and science (Hogg, 2006; Lichtenstein, Loshbaugh et al., 2007; Stevens et al., 2005; Syed et al., 2011; Tate & Linn, 2005; USDOE, 2000; Vogt et al., 2007). Due to mathematics being both an important and essential component in engineering, having a strong mathematics identity correlates to having a strong engineering professional identity. For engineering students, a mathematical identity becomes critical to the development of an engineering (professional) identity, as students' confidence in mastering college level mathematics (math self-efficacy) (Lent et al., 1991), has been associated with persistence in engineering (Burtner, 2005; Green & Sanderson, 2014; Kokkelenberg & Sinha, 2010). A strong mathematics identity reinforces a positive self-perception, which for African American females enhances their sense of connection to others and promotes ownership of their future, which then increases their motivation to continue in engineering careers (Joseph et al., 2017). Thus, if African American female students have difficulty in mathematics courses, their mathematics identity is lessened. This lowered mathematics identity can be interconnected to stereotype threat. Stereotype threat can be defined as "anxiety caused by the expectation of being judged based on negative group stereotype" (Beasley & Fischer, 2012, p. 427; Steele, 1997). In addition to already being negatively stereotyped due to their gender and race, African American female engineering students who have high mathematics identity but also struggle in their mathematics performance, experience added stress related to stereotype threat. In such, these students begin to question whether they are in the correct degree program and eventually change their majors and/or withdraw from engineering programs.

Social Identity

Social identity theory combines the roles of personal identity and social identity. These roles form an identity that is constructed upon an individual's perception of themselves, their strengths, their experiences, as well as their self-concept within group membership, processes, and relationships (Hogg, 2006). Hence, social identity roles are based upon the actual or perceived perceptions of others and can include race, gender, religion/spiritual, physical ability, socio-economic status, and sexual orientation constructs (Chachra et al., 2008; Hogg, 2006). While a strong social identity is connected to African American female engineering students' confidence in their ability to be successful (Cadinu et al., 2005), it follows that stereotype threat (the fear of being viewed through a negative stereotype or demonstrating behaviors that confirm the stereotype) could result in a negative identity, lowered confidence in professional identity, and social isolation (Candinu et al., 2005; Johnson, 2001; Malone & Barabino, 2009; Sosnowski, 2002; Steele & Aronson, 1995; Vogt et al., 2007). Ultimately, social identity is impeded and academic dis-identification with engineering ensues. Next, follows a withdrawal from engineering programs, especially during the first academic year (Atkinson et al., 1989; Bonous-Hammarth, 2000; Hogg, 2006; Lichtenstein et al., 2007; Stevens et al., 2005; Tran, 2011; Vogt et al., 2007).

Racial Identity

Research indicates that a strong racial identity fosters a healthy self-esteem and an aptitude to endure opposing and unfavorable environments (Rowley & Moore, 2002; Tate & Linn, 2005). Racial identity development models were primarily fashioned to offer African Americans' understanding and appreciation of their cultural experiences within the United States (McKoy, 2019). These models identified and explained successions of cultural consciousness from a lack of knowledge and awareness of one's racial identity to acknowledgement and

acceptance of one's racial identity and ethnic culture (Atkinson et al., 1989; Chavez & Guido-DiBrito, 1999; Cross, 1971, Helms, 1996, Phinney, 1990; Reynolds & Pope, 1991). African American women possess multiple identities including three identities (gender, race, and class) historically and traditionally connected to oppression (McKoy, 2019). The Multidimensional Identity Model (MIM) assesses identity of individuals belonging to multiple oppressed groups through four stages (Reynolds & Pope, 1991). These stages involve: individuals allowing others to determine their primary group membership (passive identification) to African American female engineering students subduing certain aspects of their identity (race, gender) for social acceptance (conscious identification) followed by these students embracing all aspects of their identities while living them as unconnected (segmented identification) and finally advancing into an identity comprised of the intersections of all identities as one unified and cohesive relationship (identity intersection).

This exploratory study examined persistence, as measured by the intent to persist, in female undergraduate students enrolled in engineering-related programs at an historically Black University (HBU). The purpose of the study was to explore the effects of social, professional, and racial identity in relation to persistence and to inform future research.

Methodology

The study employed descriptive statistics to analyze the relationship of social, racial, and professional identity to the persistence of African American female engineering students at an HBU located in the southeastern United States. The research question examined was: How does professional, social, and racial identity predict persistence in engineering?

Context and Participants

Historically Black Colleges and Universities graduate the highest percentage (20%) of African American engineers (HBCU; NSF, 2015b). Accordingly, HBCUs have been linked to an institutional culture traditionally supportive of the identity, belongingness, and academic achievement of African American students (Cokley, 2000; Ogden et al., 1905; Seifert et al., 2006). To understand the lived experiences of African American female undergraduate engineering students, it follows that the study transpires within an academic environment historically demonstrating encouragement, sponsorship, acceptance, and promotion of African American female students. This exploratory study comprised adult, African American women in undergraduate engineering programs at an HBCU located within the southern U.S (McKoy, 2017). A sample of 17.33% of the female students enrolled in the College of Engineering completed this research. The participants comprised mostly of African Americans women (69%), between the ages of 18 – 24 years (89%), and were classified as either Freshman (19%), Sophomore (15%), Junior (35%), or Senior (23%). The identified majors were Architectural (31%), Civil (27%), Electrical/Computer (23%), Mechanical Engineering (15%) and Computer Science (4%).

Instrumentation

This exploratory study used professional, social and racial identity as independent variables and intent to persist as the dependent variable. Participants completed a demographic questionnaire and a set of self-administered assessment tools including four measures (McKoy, 2017):

- (1) *Group Identification Scale (GIS)* (Chachra et al., 2008) used to measure Professional Identity is based on the Multidimensional Inventory of Black Identity (MIBI)

- (Sellers et al., 1997) which focuses on self-identification as an engineer “centrality” and the level to which the student holds positive or negative feelings about engineering or engineers (private regard), the student’s perception of others’ thoughts regarding engineers (public regard), and the value placed on being an engineer along with a sense of belonging to the engineering group (group identification).
- (2) *Social Identity Attitudes Scale* (SIAS) (Picho & Brown, 2011) measures social identity by evaluating group identification based on multiple social identities (race, gender, math), and calculates stereotype threat based upon five components: math identification, ethnic identification, ethnic stigma consciousness, gender identification, gender stigma consciousness, and negative affect.
 - (3) *My Vocational Situation Scale* (MVS) (Holland et al., 1980) comprised of three subscales, *Vocational Identity* (VI), *Occupational Information* (OI) and *Barriers* (B) identifies professional identity confusion in addition to differentiating obstacles to career choice.
 - (4) *Social Group Identification Measure* (SGIM) (Mayer et al., 2009) assesses an individual’s affinity with their university and peers. Persistence was determined by intent to persist as measured by the self-reported question, “I will obtain a bachelor's degree from this university” (Morrow & Ackermann, 2012, p. 485).

Data Analysis

Data was cleaned and exploratory data analysis was conducted to ensure data met statistical assumptions with adequate results. A forward multiple regression analysis (see Table 2) was conducted. The prediction model contained two variables [negative affect (negative feelings of dejection experienced during math test taking), and stereotype threat] which significantly predicted intent to persist [$R^2 = .372$, $R^2_{adj} = .317$, $F(2,23) = 6.798$, $p < .005$] and accounted for 37.2% of the variance in intent to persist.

Results

Descriptive statistics (see Table 1) found scores on mathematical identification (Math ID, $M = 6.24$, $SD = 0.74$) higher than ethnic (Ethnic ID, $M = 5.74$, $SD = 1.31$) and gender identification (Gender ID, $M = 4.55$, $SD = 1.38$). This implies that participants’ confidence in their mathematical competencies was more salient to them than their ethnic or gender identity.

Table 1.

Descriptive Statistics of Mathematical Competencies (N = 26)

| Variable | Minimum | Maximum | Mean Std. | Deviation |
|-----------|---------|---------|-----------|-----------|
| Math ID | 4 | 7 | 6.237 | 0.735 |
| Ethic ID | 2.5 | 7 | 5.740 | 1.307 |
| Gender ID | 2 | 7 | 4.551 | 1.379 |

Additionally, the prediction model (see Table 2) showed that both negative affect (feelings of dejection experienced during mathematical test-taking) and stereotype threat as significant predictors of intent to persist [$R^2 = .372$, $R^2_{adj} = .317$, $F(2,23) = 6.798$, $p < .005$]. To sum up, these exploratory findings support previous research that found mathematical confidence a significant factor of persistence in engineering (Lichtenstein et al., 2007).

Table 2.

Model Summary of Predictors of Persistence

| Model | R | R ² | R ² _{adj} | Std. Error | R ² change | F change | Sig. F change |
|-------|--------|----------------|-------------------------------|------------|-----------------------|----------|---------------|
| 1 | 0.470a | 0.221 | 0.188 | 1.166 | 0.221 | 6.801 | 0.015 |
| 2 | 0.610b | 0.372 | 0.317 | 1.07 | 0.151 | 5.516 | 0.028 |

a. Predictors: (Constant), negative feelings of dejection experienced during math test taking (negative affect)

b. Predictors: (Constant), negative affect, stereotype

A forward multiple regression analysis was conducted to evaluate the multiple social identities. Regarding professional identity, this study found that the value placed on being an engineer and the value of belonging to this group (group identification, $M = 45.81$, $SD = 8.01$) was higher than the extent students defined themselves as engineers (centrality, $M = 38.42$, $SD = 7.01$). This suggests that the study participants viewed themselves as lacking attributes or skills needed to perceive themselves as engineers. Regarding social identity, becoming an engineer and belonging to the group was higher than the degree participants felt about engineering (private regard, $M = 38.04$, $SD = 4.42$). In other words, becoming an engineer and fitting in was more important than what participants thought about the actual program of study for the engineering discipline. Finally, becoming an engineer and belonging to the group was more important to participants than other individuals' views and perceptions of becoming an engineer (public regard, $M = 35.58$, $SD = 5.33$).

Conclusion

Although a limitation of this study was a small sample size, results from this study demonstrated that professional identity, stereotype threat (fear of being viewed through a negative stereotype or demonstrating behaviors that confirm the stereotype), and negative affect (negative feelings of dejection experienced during math test taking) accounted for 37.2% of the variance in intent to persist. These findings are similar to research-based inferences of stereotype threat and weakened professional identities as barriers to African American women persisting in engineering programs. When exploring multiple identities, this study also highlighted that participants viewed their mathematics identity higher than their ethnic and gender identity. This reinforces the importance and value participants placed upon their mathematical ability and performance to their engineering professional identity. Regarding professional identity, the participants valued being an engineer and belonging to the group as key components. As extant literature shows, African American female students enter engineering undergraduate programs confident and strong in mathematics; a strong math identity becomes a meaningful factor in African Americans level of confidence in their ability and skill to become engineers (professional identity). Thus, when faced with psychological dissonance of ability and failure, African American female undergraduate students may choose to withdraw from engineering programs, resulting in negative persistence of African American women in engineering careers.

Due to participants' lowered importance of racial and gender identity to their mathematics identity, it can be surmised that these students have gained sufficient experience to traverse negative environments encompassed with racial and gender bias into their self-confidence and self-efficacy. However, it may also represent the fact that because these participants attended an HBCU, a supportive and encouraging environment may serve as protective factors against racial and gender bias, thus promoting academic achievement and persistent in engineering-related career fields.

Future research should be conducted to support and extend these findings. This study heightened the awareness regarding the connection and significance of math identity to persistence of African American female engineering undergraduate students. Additionally, these results support the need for continual focused efforts regarding the connection of mathematics identity and sense of belonging to professional identity. Therefore, it is with optimism to conclude that the results of this study are indicative of higher-education reform needed to consistently assess college climates at Historically Black Colleges and Universities. Also, these results infer the necessity of encompassing multicultural-based improvements in support of African American females in mathematical and engineering-related courses.

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