# Board 107: Explaining Choice, Persistence, and Attrition of Black Students in Electrical, Computer, and Mechanical Engineering: Award# EEC-1734347 - Year 1

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Her research team is skilled matching these newer manufacturing techniques to distinct material choices and the unique materials combination for specific applications. She is also renowned for her work in the Engineering Education realm working with faculty motivation for change and re-design of Material Science courses for more active pedagogies

**Explaining Choice, Persistence, and Attrition of Black Students in Electrical, Computer, and Mechanical Engineering: Grantee Poster Session - Year 1**


## Abstract

The objective of this project is to identify policies and practices that influence choice, persistence, and attrition of Black students in Electrical Engineering (EE), Computer Engineering (CpE), and Mechanical Engineering (ME) and to make actionable recommendations for policy makers regarding best practices. Building on prior work that demonstrated the impacts of gender and race on academic trajectories for engineering as a whole and EE, CpE, and ME in particular, our transformative mixed-methods project responds to calls for more cross-institutional qualitative and longitudinal studies of minorities in engineering education. The study will investigate the following overarching research questions:

1. Why do Black men and women choose and persist in, or leave, EE, CpE, and ME?
2. What are the academic trajectories of Black men and women in EE, CpE, and ME?
3. In what ways do these pathways vary by gender or institution?
4. What institutional policies and practices promote greater retention of Black engineering students?

Our mixed-methods approach combines the quantitative power of large sample sizes available from the Multi-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) and the qualitative richness of 80 in-depth interviews and detailed content analysis of institutional policies and contexts at four institutions. This approach allows for the development of the thematic rigor necessary to advance theoretical understanding of engineering education for underrepresented minorities (URMs). We will draw on the theoretical frameworks of intersectionality, critical race theory, and community cultural wealth to guide our research and interpret our findings.


## Introduction

### The need to diversify engineering

In recent decades, the emphasis on increasing the number of engineering graduates has been coupled with greater concern about the lack of diversity in engineering fields. Research has identified the benefits of identity diversity (race, ethnicity, gender, socioeconomic status, etc.) in engineering education, including more innovative groups [1], greater engagement in active thinking processes, growth in intellectual engagement and motivation, and growth in intellectual and academic skills [2, 3]. A variety of educational policies and programs have been initiated to boost participation and increase graduation rates of URMs in engineering education.

However, despite numerous calls to diversify engineering [4, 5] and despite the initiation of these policies and programs, there is still a lack of diversity in engineering bachelor's degrees awarded to people of color; this lack of diversity is subsequently reflected in the professions [6]. The majority of undergraduate engineering degrees in the U.S. are awarded to students who identify

as White. In 2015, Whites received 65% of the engineering Bachelor's degrees, Asians over 13%, and Hispanics nearly 11%. Blacks received 4% of all engineering degrees [7], an increase from 2014 and reversing a nine-year decline from 5.3% in 2005 to 3.5% in 2014 [8]. The representation of minorities among engineering graduates is not keeping pace with the changing demographic landscape of the general population or undergraduate population of the 21st century.

This lack of diversity in engineering educational and career pathways has been identified as a national security issue [9] and a "workforce train wreck" [10, p. v], representing a significant loss of human capital in the labor force and ultimately reducing the United States' global competitiveness [3, 5]. There is a critical need to develop federal and state policies and programs and innovative educational programs to increase minority representation in science, technology, engineering, and mathematics (STEM) majors [11]. Further research, focusing on the conditions under which Black students are successful, is needed to more clearly identify the factors contributing to URM's entry into and exit from engineering disciplines.

**Differences across engineering majors**

While there are commonalities across many engineering fields, there has been research demonstrating substantial differences across engineering majors and their teaching approaches and students' experiences. Lattuca and her colleagues' [12] research on the culture and values of engineering disciplines demonstrated that disciplinary contexts shape faculty members' attitudes and behaviors. Recent research explores the idea of the culture of engineering education and the need to understand this culture before we can effect systemic change [13, 14]. For example, Godfrey [15] showed that different engineering disciplines exhibited different cultures, or "cultures within cultures," affecting the participation of women.

Our project explores the different disciplinary cultures of EE, CpE, and ME as these fields provide a sharply contrasting picture of engineering matriculation, persistence, and attrition for Black students. EE is one of the largest and oldest engineering disciplines, dating back to the 1880s [16]. CpE is frequently combined with EE in a single department, but it has much different student demographics and outcomes [17]. Both EE and CpE attract an above average percentage of Black males and females compared to other engineering disciplines [18]. ME dates back to the 19th century and is currently the largest engineering discipline [19], awarding 23.8% of engineering degrees in the U.S. and Canada in 2015 [7]. ME attracts a smaller percentage of Black engineering students, but is better at retaining them (especially females) to graduation [20].

**Campus and classroom climate influence student persistence**

Brown, Morning, and Watkins [21] surveyed African-American engineering students to learn about the influence of campus climate on their graduation rates and analyzed the climate findings as they related to the selectivity of their institutions and whether the institutions were HBCUs (analyzed as a group without regard to selectivity). They found a correlation between selectivity and graduation rates ranging from 50% in the high selectivity group to 29% in the less selective group. The graduation rate for HBCUs was 37%. The researchers also found that HBCU students

have a much more favorable perception of campus climate, particularly in the area of racism and discrimination, than students at other institutions, regardless of selectivity. Higher graduation rates were associated with lower perceptions of racism and higher commitment of the student to the institution [21]. In their discussion of policy implications, the authors suggest that "the wide disparities in African-American engineering graduation rates among institutions that appear to be academically similar is an important topic that should be thoroughly examined" [21, p. 269].

In studying the risk of attrition among engineering students using the Project to Assess Climate in Engineering (PACE) survey, Litzler and Young [22] classified engineering students from 21 institutions (including four original MIDFIELD institutions) as being "Committed," "Committed with Ambivalence," and "At-Risk of Attrition." The authors used demographic, in-school characteristics (e.g., class year, GPA, transfer), and student experiences and perceptions (e.g., confidence, peer interactions, faculty/TA quality, professors value students) as the predictor variables to build three models. Using only the demographic variables, they found that African-Americans are more likely to be in the Committed with Ambivalence group than Whites, but when experience variables are added, being African-American is no longer predictive of group membership. They conclude that student experiences and perceptions play an important role in predicting how committed students are to their major.

Research has shown that student classroom experiences impact students' retention and persistence. A review of the research on strategies for improving classroom climate [23] cites numerous studies that found that positive faculty-student interactions can help students develop an engineering identity and lead to greater persistence. In addition, research indicates that pedagogies of engagement (i.e., cooperative, problem-based, project-based, case-based, and service learning) result in greater social integration and academic learning. Perceptions of belongingness in the classroom are especially important for retention. One study identified four factors as particularly important for minority students—instructional styles that promoted activity and engagement, positive interpersonal relationships with faculty, feelings of connectedness in the classroom, and positive interaction with peers [24]. Building on these studies of student experiences, our mixed-methods approach will allow us to delve further into *how* and *why* such experiences and perceptions contribute to commitment to major, persistence and retention.

**Research Questions**

As highlighted in our literature review, Black students experience diverse pathways into, through, and out of engineering that vary according to discipline. We are using a transformative mixed-methods design [25] to answer the following overarching research questions:

1. Why do Black men and women choose and persist in, or leave, EE, CpE, and ME?
2. What are the academic trajectories of Black men and women in EE, CpE, and ME?
3. In what way do these pathways vary by gender or institution?
4. What institutional policies and practices promote greater retention of Black engineering students?

## Theoretical Framework

Our mixed-methods approach for studying the experiences of URMs in engineering is informed by several theoretical foundations: intersectionality, critical race theory, and community cultural wealth theory. Intersectionality explains how gender operates together with race, not independently, to produce multiple, overlapping forms of discrimination and social inequality [26-29]. Critical race theory (CRT) [30] recognizes the unique experiences of marginalized groups and strives to identify the micro- and macro-institutional sources of discrimination and prejudice. Community cultural wealth integrates an asset-based perspective to our analysis of engineering education to assist in the identification of factors that contribute to the success of engineering students [31].

Intersectionality has been used effectively in modern engineering education research to elucidate stories that would otherwise remain hidden, such as the MIDFIELD team's research on majority measurement bias in studies of persistence [32] and Riley and Pawley's work critiquing myths of gender and race in engineering education [33]. However, the multiple identities beyond these two commonly used aspects of a person's positioning necessitates that researchers think more deeply about how, for example, two black women pursuing an engineering degree navigate their programs based on their socioeconomic and family backgrounds. Several studies provide a starting point for this kind of analysis, including Foor, Walden, and Trytten's rich ethnography of one female multi-minority student [34] which provides "a microphone for the voices of the marginalized to be heard," and other studies of how social categories (such as age, race/ethnicity, class, gender, ability, and sexual identity) are enacted in engineering [35-37].

Our application of CRT advances a framework that acknowledges White privilege and its consequences in preserving that power over time in engineering education. Focusing on the mechanisms of institutionalization, our work considers the dual roles of campus micro-climates within each discipline, and the policies of each institution in maintaining the status quo [30]. Previous research has shown that common ways of measuring success in engineering education are often characterized by a systematic measurement bias that masks and maintains White privilege [32]. CRT provides a space for Black students' counternarratives, making a valuable contribution to engineering education to deepen our understanding of how students navigate the structural biases and institutional racism that influence engineering persistence. This is critical given the CRT premise that because racism is pervasive in our society, African-Americans may not consider entering a profession (engineering) that is dominated by white males.

We will also draw on the theoretical framework of community cultural wealth theory to more fully consider the assets that URMs bring to engineering education and the strategies they use to succeed. This anti-deficit approach [38] allows for a deeper understanding of the assets that people of color and minority groups bring to their educational pursuits. According to Yosso [31], community cultural wealth resides in six types of attributes, assets: family, social, linguistic, aspirational, resistant, and navigational. This approach has been used to study how young children learn about engineering [39] and to investigate the persistence of African-American and Latino students through their engineering studies [40].

## Research Methods

This project builds on extensive prior research conducted using the MIDFIELD database and incorporates a substantial addition of qualitative data. This work will advance the prior studies by further analyzing the trajectories of Black students in EE, CpE, and ME in the MIDFIELD database, and interviewing Black students who persisted in those majors and others who have switched to other majors (both within and outside of engineering) at their institutions. As depicted in Figure 1, our goal is to identify policies and practices that lead to different outcomes for Black students in three engineering disciplines with substantially different patterns of enrollment and persistence, and to make actionable recommendations for policy makers, practitioners, and teachers regarding best practices.

Following the collection of the qualitative data, we will use those results to shed light on the patterns noted in the quantitative analyses in this and prior studies. We also have the potential to ask new questions of the MIDFIELD data, paralleling Brawner and colleagues' study of women in chemical engineering [41]. This iterative approach will strengthen our development of individual case studies and to draw comparisons across our five study sites. This comparative case study approach will be strengthened through the integration of information about institutional policies and contexts. We draw from Yin's case study framework that involves explanatory inquiries, focuses on "how" and "why" questions, and is conducted through the collection and comparison of data across multiple sites [42]. The resulting qualitative data will offer rich thick description about the experiences of Black students in engineering that we would not otherwise be able to obtain; the quantitative MIDFIELD analyses will allow us to contextualize these experiences. Each element of the study is described in more detail in the section below.

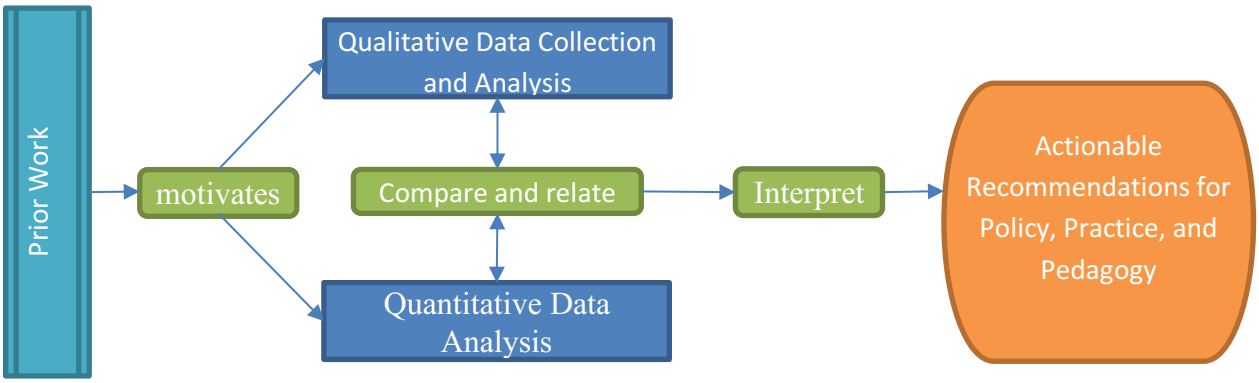


***Figure 1. Schematic of Research Plan***

### Mixed-methods analysis

Our mixed-methods approach presents us with a unique opportunity to query both the qualitative and quantitative data sources more deeply in an iterative fashion. That is, analysis of the early interview data will undoubtedly lead to new questions, which may be asked in subsequent interviews and probed through additional queries of the MIDFIELD database. For instance, interviewees may reveal certain educational pathways that can be tested for generalizability with the whole of the database, or interview data may support previous findings of significant

institutional differences in the performance of Black students in MIDFIELD. This collaborative, iterative approach, which capitalizes upon the strengths of mixed-method research, has been used in prior MIDFIELD work on engineering education. Our creation of variables that reflect contextual factors and will result "in richer interpretations and, in some cases, provid[e] critical information for sense-making" [43, p. 14]. MIDFIELD data will be used to assess the frequency of response patterns that arise in the interviews. For example, if student responses speak to a lack of academic preparation, MIDFIELD could be queried using academic preparation variables, such as SAT scores or high school GPA, to learn if the interviewees' experience and pathway is reflected in the overall data on Black students in EE, CpE, and ME.

**Outcomes and Broader Impacts**

A large body of literature over many years has studied the experience of women and underrepresented minorities in engineering. MIDFIELD findings by members of this research team have dispelled popular myths, received nationwide media coverage, and earned four best paper awards in journals. Ongoing research has described disciplinary variation within engineering. Another important impact of MIDFIELD research includes speaking with a strong voice about the importance of disaggregating by race/ethnicity and gender. For our work to have the greatest potential to transform practice, we have developed a significant qualitative component that explores the reasons for these variations—adding the voices of students to large-scale longitudinal findings.

The addition of a qualitative component will allow us to more fully consider institutional and contextual factors shaping student outcomes. The mixed-methods nature of this study will include quantitative findings from a population too large to ignore while the collective voices of individual students in the qualitative work will emphasize the need for practices that both attract and retain a diverse population. The integration of the quantitative and qualitative results will be the basis for actionable policy and program recommendations.

To further expand the broader impact of our work, our quantitative data are voluminous enough to allow us to consider several elements of diversity, including race/ethnicity, gender, and peer economic status (as a proxy for socioeconomic status) using intersectionality [26-29] and critical race theory frameworks [27, 30].

The increased call to diversify engineering educational and career trajectories indicates a recognition that merely expanding the number of URM engineering students does little to strengthen student experiences because underrepresented groups face continuous barriers to engineering education and the engineering economy. Indeed, the pathways have become narrower over time, with little progress in truly diversifying engineering education. As a result, our society stands to lose a significant pool of human and social capital in the engineering workforce. We contend that this lack of progress results from a limited understanding of the actual experiences of underrepresented students in key engineering disciplines. Our transformative mixed-methods approach will help to expand our understanding of the factors that have limited the full participation of Black men and women in EE, CpE, and ME, as well as help us identify the positive factors that can attract and retain them in these fields.

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