

## Overview of Policies and Programs to Retain Black Students in Engineering

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### **Abstract**

In this work in progress, we use Lee and Matusovich's model of co-curricular support (MCCS) and the recruitment aspect of the Building Engineering and Science Talent (BEST) framework to investigate the policies, programs, and activities for, and recruitment and retention of, underrepresented students at four institutions. These four colleges of engineering are in the top 15 nationally in engineering bachelors' degrees conferred on Black students. This information will provide background for a mixed-methods study on the choice, persistence, and attrition of Black students in computer, electrical, and mechanical engineering and is a critical first step to contextualize the student experiences to be revealed in individual interviews. We use publicly available information from web-based and other resources as well as interviews with key informants on each campus to ascertain the programs that are available on each campus and categorize them using the MCCS and BEST frameworks. This study lays the groundwork for future institutional data analysis and interviews with Black students currently or formerly enrolled in computer, electrical or mechanical engineering to uncover what causes them to enroll and persist in or leave these majors.

**Keywords:** Race/ethnicity, undergraduate programs, support programs, MIDFIELD

### **Introduction**

The educational trajectories of engineering students vary by gender and race, yet little is known about the persistence and attrition of Black students in engineering subdisciplines. Prior research has shown that electrical, computer, and mechanical engineering each have unique patterns of attraction, persistence, and attrition for different race-gender groups [1-2]. In particular, electrical and computer engineering are relatively better than mechanical engineering at attracting Black students. Lord and colleagues found that 30% of first time in college (FTIC) Black males and 22% of Black females starting in engineering started in electrical engineering and another 12% each of Black males and females started in computer engineering [1]. By comparison, only 19% of Black male and 10% of Black female engineering starters began in mechanical engineering [2]. Conversely, mechanical engineering (ME) is relatively better at retaining students to graduation. In ME, Black women starters are far more likely than Black men to persist to graduation (42% to 34%), although both Black men and women persist at a higher rate in ME than in the combination of all other large engineering majors [2]. In electrical engineering (EE), Black women (36%) are slightly more likely to persist to graduation than Black men (32%), whereas in computer engineering, Black men (17%) are more likely to do so than Black women (14%), though the graduation rate of both is abysmally low. Black women starting in computer engineering (CPE) are more likely to graduate in another engineering major than in CPE [1].

To shed light on how and why these patterns emerge, our research team has embarked on a three-year mixed-methods study at four colleges of engineering that are members of the expanded MIDFIELD (Multiple Institution Database For Investigating Engineering Longitudinal Development) partnership to explore in depth the issues that may explain them. These colleges

represent both Historically Black Universities (HBCUs) and Predominantly White Institutions (PWIs) and all rank in the top 15 nationally in the number of engineering baccalaureate degrees conferred on Black students [3]. Our approach includes a quantitative study based on prior MIDFIELD research with an expanded and updated dataset and in-depth interviews with Black students who are enrolled in CpE, EE, and ME or have switched from them. The quantitative analysis will use historical data from the institutions to complement qualitative findings by examining academic trajectories of Black students. To lay the groundwork for those two aspects of the study, we began by conducting an environmental scan of the publicly available information about policies and programs for Black students in those colleges and spoke to key informants who could provide further details about these policies and programs. The information will provide important contextual data for understanding the results of our key informant interviews and in-depth interviews with former and current majors in ME, CpE, and EE. This paper highlights the information that we have uncovered in the early stages of our research about these programs and their intended purpose.

## **Literature Review**

### *Minority Programs in Engineering*

Secules contends, “diversity support programs represent a critical response on the front lines of addressing the diversity issue” [4, p. 8]. Additional literature has documented the importance of programmatic efforts, such as informal mentoring, co-curricular programs, support centers for engineering students, and living-learning programs [5]. Gándara and Maxwell-Jolly revealed that many minority student success programs focused on a combination of mentoring, financial support, academic support, psychosocial support, and professional opportunities [6].

A Building Engineering and Science Talent (BEST) report recognized common characteristics among institutions that have been successful at increasing diversity in engineering by broadening participation of underrepresented minorities. These characteristics included institutional leadership, targeted recruitment, engaged faculty, developing student talent as a rewarded faculty outcome, personal attention, peer support, enriched research, bridging to the next level, and continuous evaluation [7]. Lee and Matusovich found that the goals of these programs may vary by the target populations [8].

The National Action Council for Minorities in Engineering (NACME) program at Arizona State University was implemented with the purpose of increasing retention and recruitment rates of minority students in engineering and computer science to rates that are comparable to non-minority students. Additionally, this program aimed to get more minority students to go to graduate school [9]. This program uses a combination of four retention models including a summer bridge program, year-long bridge program, minority engineering program, and academic scholarship program. This multi-faceted approach yielded promising results. Over a five-year period, 47.6% of the first cohort of NACME scholars either remained in engineering or had already graduated in engineering. This rate was higher than the rate for minority students who were not NACME scholars (21.2%) and the rate for non-minority students (40.8%).

## *Analytical Framework*

The Model of Co-Curricular Support (MCCS) for undergraduate engineering students was developed by Lee and Matusovich [8] as an extension and alteration of Tinto's model for institutional departure [10]. They examined six Engineering Success Support Centers (ESSCs) and developed a conceptual model of the practices and intentions of ESSCs. These support centers included minority engineering programs (MEPs), women in engineering programs (WEPs), and diversity in engineering programs (DEPs). Earlier, Lee and Matusovich [11] found that though student success is a key outcome of all of these programs, they differ in their target student groups. While minority engineering programs focus on minority students and women in engineering programs focus on women, diversity in engineering programs focus on all engineering students but target underrepresented populations. This study examines the ESSCs from the perspectives of the administrators and well as the students.

The MCCS is comprised of multiple interventions and intentions, categorized by inputs, outputs, short-term outcomes, medium-term outcomes, and long-term objectives. The inputs portion of the model includes interventions provided by the administrators. The outputs portion includes the parts of the undergraduate experience that the ESSCs hope to impact. The short-term outcomes are types of integration experiences. Medium-term outcomes are the intentions, goals, and institutional commitment that the ESSCs are hoping to instill. Long-term objectives are the accomplishments that the ESSC administrators want the students to attain.

The inputs portion of the Model of Co-Curricular Support lists the interventions used by the ESSCs to support their students. Interventions from this model include programs, activities, and services. These three interventions are defined by Lee and Matusovich as follows: "Program refers to an interconnected set of experiences that requires prolonged involvement. Activity refers to a condensed experience that does not require prolonged involvement from participants. Service refers to a regularly available form of assistance or resource" [8, p. 418]. Their study revealed 29 interventions among the six ESSCs housed at four different universities. The MCCS was chosen as a framework for this study in the hopes that an examination of the support programs at these institutions would aid our understanding of the persistence and attrition patterns of Black students in mechanical, electrical, and computer engineering.

## **Methods**

Our research team scanned university, college of engineering, and Electrical and Computer Engineering (ECE) and Mechanical Engineering (ME) websites at the four partner colleges of engineering under study. We followed links related to curriculum, minority engineering programs in the colleges of engineering, living and learning communities (LLCs), student organizations, and the like. We also interviewed "key informants" on each campus in such roles as Associate Dean for Undergraduate Students, advisors in ME and ECE, first-year advisors, heads of minority engineering programs, and heads of student services organizations serving diverse students. Key informants were asked, as part of a semi-structured interview, to describe the various programs that they provide to all students generally and Black students in particular, and the intended and actual outcomes of such programs.

All four institutions are public and located in the southern United States. Total undergraduate enrollment at these four schools ranges from about 12,000 to over 25,000 students. Undergraduate engineering enrollment ranges from less than 1500 students to more than 6000. We present these findings below using pseudonyms for the institution names and obscuring institutional characteristics and program names to preserve institutional anonymity.

## **Findings**

Our study was conducted as an investigation of the policies and programs currently in place at the study institutions, thus we will only be addressing the inputs portion of the MCCS here. The information will provide important contextual data for understanding the results of our key informant interviews and in-depth interviews with former and current majors in ME and ECE. Using Lee and Matusovich's "Inputs" framework [8, Table 6, p.418] as a guide, we highlight the programs, activities, and services that we found through our environmental scan at the four study institutions, shown on Tables 1-3 below. We include some programs available to all students or other underrepresented groups (e.g., women in engineering, first generation) as these programs are always open to, and may also benefit, Black students. Though not part of the MCCS framework, we also include programs and activities with a recruiting objective in Table 4 as they are important to our larger study.

### *Programs*

Lee and Matusovich identified nine "interconnected sets of experiences that require prolonged involvement" [8, p. 418]. Our scan found that four of these - mentoring programs, summer bridge programs, living/learning communities (LLCs) and undergraduate research programs - were on all four campuses. Extensive mentoring programs serve African-American men, African-American women, first-year African-American men, African-American men in EE, first-year minority students, transfer students, and students generally. Mentors may be part of the living/learning communities or simply upper class students of the same ethnicity/gender/major as the mentee. Activities that are part of the mentoring programs include professional development, service projects, and social components.

Summer bridge programs were targeted either narrowly to minority (including Black and Hispanic) students only or more expansively to minority, first generation, women, and students from economically disadvantaged backgrounds. Summer bridge programs are generally five to six weeks in length, running concurrently with a summer school session and may include remediation or acceleration in math and science courses as well as the first semester engineering class when one is offered. These programs seek to prepare students for the rigors of undergraduate engineering study by helping those whose high school background may have left them underprepared, with a particular emphasis on math skill development. They also help to create a cohort network for underrepresented students in PWIs. Other activities within these programs include study skills development, professional development, social activities, mentoring, and corporate exposure.

LLCs were primarily for first-year students and may be either for engineering specifically or STEM more broadly. One PWI has LLCs for engineering students, women in STEM, and Black

men in any major. Another institution has LLCs specifically for STEM students, Black women, Black men, and first generation students. All are coordinated through university housing and there is often an application process, occasionally with high school grade point minimums and essays. One institution, in addition to LLCs, has non-residential learning communities (LCs) that allow students with similar interests in STEM or engineering to take advantage of some of the programming offered by the LLC. Programming within the learning communities usually includes a mentoring component, tutoring in core math and science classes required for engineers, professional development seminars, study skills, and a social component.

Undergraduate research experiences with engineering faculty were offered at all four campuses. These experiences were offered during the academic year at two institutions and as summer programs at two others. In one case, the research program was an extension of an LLC. Designed for sophomores, its purpose is to connect students to engineering while they are still generally taking prerequisite math and science courses and general education requirements.

We considered success skills, professional development, and engineering concepts that were offered in the context of a required first year engineering course to fit Lee and Matusovich’s definition of first-year seminar. We only found a few instances of professional seminars, activity clusters, and a scholar program and no instances of student leaders. That is not to say that there are not student leaders but rather that developing them does not seem to be the purpose of any particular program. Professional seminars, geared toward professional development, and activity clusters, a group of activities making up a program, appeared to be activities incorporated into the LLCs or summer bridge programs. Only one school has a pre-professional scholars program which is designed to prepare students for entry into STEM professional schools. These findings are summarized in Table 1.

Table 1. Programs for Underrepresented Students at Study Institutions

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Mentoring program	Mentoring team for all students; includes recruiting and ambassador responsibilities	Peer mentoring for 1st years and transfers.  Tiered mentoring in small mentoring groups  Community mentors for Black Males as part of larger program for minority students.	Centrally coordinated mentoring programs for all students.  Mentoring for Black men in EE  Peer mentoring through housing office  SWE offers mentoring in engineering	Mentoring for 1st year minority engineering students  Mentoring a component of women in STEM and 1st year engineering LLCs

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Learning community	<p>Engineering LLC for Black 1st year students</p> <p>Engineering Learning Community for Black students without a residential component.</p> <p>STEM Learning Community for all students.</p>	Women in STEM LLC	<p>1st year STEM LLC</p> <p>Black men LLC</p> <p>Black women LLC</p> <p>1st generation LLC</p>	<p>Women in STEM LLC for 1st years and some 2nd years as mentors</p> <p>Engineering LLC for 1st year engineering students</p> <p>Black men LLC</p>
Summer bridge program	<p>6-week summer experience for minority engineering students</p> <p>Summer program for 1st generation and economically disadvantaged students in any major</p>	5-week summer program for minority students	<p>5-week summer program for minority engineering students</p> <p>5-week summer program for high achieving STEM students as a recruitment and retention initiative</p> <p>Summer bridge program for 1st generation students who are part of 1st generation LLC</p>	5-week summer program for minority students
First-year seminar	Success skills included as part of required 1st year engineering course		<p>Engineering success seminar</p> <p>College success seminar for all students</p>	<p>Success skills included for all students as part of required 1st year engineering courses</p> <p>Separate success skills two course sequence for minority students</p>
Professional seminar	Included as part of engineering LLC			Included in summer bridge program
Undergrad research program	Designed for sophomores who were part of LLC and Engineering LC	10-week summer program for minorities, women, and 1st generation students	Faculty mentored research experience for all students	6-week summer program for minority students

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Activity cluster	Continuous engagement with LLC and Engineering LC students after 1st year  STEM learning communities include weekly workshops			
Scholar program			Pre-professional scholars program to prepare students for entry into STEM professional schools	
Student leaders	Not found at any of the study institutions			

### *Activities*

Lee and Matusovich include 10 items under the Activity category [8]. What distinguishes activities from programs or services is that they tend to be limited in time and scope – a workshop, conference, or orientation – and not something that requires a prolonged commitment. The most well-developed activity present on all four campuses is orientation. Activities are offered in the summer for incoming first-year students including some opportunities for extended activities such as volunteer service or outdoor adventure. Underrepresented minority (URM) students are encouraged to participate in extended bridge programs described in the program section which serve as focused orientation activities. In addition, all of the campuses have a range of fun semester kick-off activities to welcome all students to the campus.

The remainder of the activities are much harder to find on campus websites and may be present to a greater extent than Table 2 indicates. Examples include activities to showcase majors, leadership development, and banquets. Many of the activities are combined with programs. For example, on one campus, a mentoring program for African-American males includes mentoring, leadership development and extensive opportunities for networking and learning about the professional world.

Table 2. Activities for Underrepresented Students at Study Institutions

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Preview event			Transfer student open house	Preview weekend for minority students  Engineering open house



	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Professional event	<p>Corporate networking opportunities</p> <p>NSBE chapter sponsors networking events and creates a resume book</p> <p>Companies invited to engineering Senior Design Day</p>		<p>Undergraduate Research Symposium - invites corporate partners</p> <p>Career fairs and similar events</p> <p>Conferences and events focused on diversity in STEM</p> <p>LSAMP Annual Research Conference</p>	Engineering Career Fair each semester for internships and full time jobs. Open to the public
Leadership conference		One sponsored by Black Men's organization	Diversity leadership conference	
Event cluster			Diversity-related workshops offered through the Multicultural Student Center	Engineering LLC includes numerous welcome, social, outreach, game, contests, etc. for 1st years
Banquet			<p>College of engineering student organization awards annually</p> <p>Order of the Engineer Ceremony for all graduating seniors</p>	
Organization showcase			Sponsored by Student Activities Center	
Orientation	Two-day orientation programs are offered for first-years and transfer students	<p>Orientation for all new 1st years and transfers includes immersive volunteer and outdoor experiences to help students form connections with peers and connect with a mentor</p> <p>Extended orientation program</p>	<p>Typical orientation programs offered</p> <p>Extended orientation program</p>	Typical orientation + registration for 1st semester based on placement test results.

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Semester kick-off	Pizza party	Wide range of opening activities of all types	New Student Convocation/ Induction (campus-wide)	Welcome Week - includes mixer and info about engineering programs and opportunities
Study session		Offered through minority services office	Supplemental instruction in classes with a high failure rate	Offered in Engineering LLC
Workshop			STEM student development workshops	

### *Services*

The MCCS framework identifies 10 services that are designed primarily to support students academically rather than socially. All four campuses offered informal advising to engineering students. This advising is offered through a variety of channels, including a drop-in basis specifically for engineers (offered through the Women in Science and Engineering LLC), offering a GPA planner and calculator, and pre-engineering advising. Campuses also made use of software programs, such as *Grades First*, that serve as a sort of “early warning” system for students who may be experiencing challenges in their engineering courses or elsewhere. Such data analytics systems have proven to be essential for identifying and retaining students at risk of dropping out of school [12].

Tutoring was integrated into all four universities’ slate of services offered to students. Three of the four campuses offered intensive tutoring for lower-division mathematics courses and for STEM courses with high DFW (grades of D, F, or Withdrawal) rates. In some cases, a department identified a specific course, or several courses, that received special attention (e.g., circuits and digital electronics). One institution mandated that all mechanical engineering students attend tutoring, or informal study sessions, for pre-calculus and calculus. Tutoring is provided through a variety of structures, including group tutoring and more personalized, intensive “peer-to-peer” tutoring.

We found evidence that two of the four schools had a study hall of some sort. For example, the NSBE chapter at Big State University, offered twice weekly study halls and the women in engineering group and the Black men’s LLC at Southern State offered study halls. Services offered at the study institutions are summarized in Table 3.

Table 3. Services for Minority Students at Study Institutions

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Informal advising	Pre-engineering advising provided where 1st year students attend classes	Offers a GPA planner and calculator	<i>Raising Grades</i> (ME) or <i>Grades First</i> (EE) Software to alert if a student is having problems	General advising built into Engineering LLC and Women in STEM LLC has drop in advising for engineers weekly
Tutoring	ME drop-in Help Center for all students staffed by TA's for help with early-curriculum high failure classes.  Tutoring offered for lower division math/science classes  ECE tutoring program for 4 ECE classes where students tend to struggle most	Tutoring and study groups through minority student office  Peer mentoring also includes tutoring in the small mentoring groups	Academic help center; writing help center  Engineering college offers Structured Supplemental Instruction  Mandatory tutoring for pre-calculus and calculus I for ME students.  ECE offers tutoring for courses with high DFW rate	Provided for students in Engineering LLC and Women in STEM LLC for common science and engineering courses
Course clustering	STEM interest group includes cohort scheduling for seminar, chemistry, and math			College of engineering registers all 1st semester students for math and science courses and attempts to create cohorts.  Engineering LLC students are cohorted into 2 Intro to engineering courses
Student lounge		Learning and Resource Center and Engineering diversity office have places for students to hang out		Engineering Library includes substantial lounge areas  Women in STEM LLC has a lounge
Study hall	NSBE chapter offers twice weekly study halls			Women in STEM LLC helps form study groups. Black male LLC includes study halls.

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Learning center	Center for Academic Excellence for all students.  Center for first generation 1st year students provides academic assistance to targeted students	Center for Academic Success for all students	Center for Academic Excellence for all students,	Center for Academic Success for all students  Engineering LLC has a “Student Success Suite” with in-hall tutoring for required courses
Resource library			Multicultural Student Center Resource Library  College of Engineering Library of Resources	

### *Targeted Recruitment*

The MCCS is an excellent framework for categorizing and clarifying programs, activities, and services for students who are already in school. However, within the context of our larger study of the enrollment, persistence, and attrition of Black students in engineering, it is important for us to also consider how students are recruited into engineering at these institutions. Targeted recruiting practices are one of seven vital elements of the BEST model [7] and our environmental scan revealed a number of practices that the institutions engage in to attract students, particularly minority students, to their engineering programs. These include alternate pathways into engineering programs for students who may not be fully qualified (i.e., are not calculus-ready) or who are economically disadvantaged, K-12 outreach to engage younger students with engineering concepts and diversify the pipeline into universities, student ambassadors who visit high schools and welcome new students, and targeted scholarships to ease the financial burden for highly qualified minority students. These programs are summarized in Table 4.

Table 4. Targeted Recruitment Activities

	<u>Big State</u>	<u>Large State</u>	<u>Medium State</u>	<u>Southern State</u>
Alternate Pathways to Engineering	<p>Local community college grads guaranteed admission to the institution</p> <p>Program for underrepresented students who do not meet the criteria for regular admission, but who have potential to succeed in college with some assistance</p>	Dual degree program with many schools including HBCU's designed to diversify engineering student body	Dual-degree program with 8 partner institutions, including HBCU's	<p>People not admitted to engineering may be admitted to Freshman College and qualify after 1st year</p> <p>2+2 programs with partner community college and other state universities includes on-site engineering faculty. Successful students can transfer.</p>
K-12 outreach	<p>Engineering outreach to local county schools to increase academic preparedness, college readiness, career and technical skills for 6-12th grades</p> <p>Learning Center in downtown Capital City is K-12 outreach arm of college</p>	Women in Engineering offers a variety of K-12 outreach programs for girls	<p>Outreach program to promising Latino high school students</p> <p>Corporate sponsored STEM program for middle school boys</p>	Engineering sponsored extension program for K-12 includes programs for kids and teachers
Student Ambassadors	Ambassador component of mentoring program	Minority Student Ambassadors	College of Engineering Ambassadors	Engineering Ambassadors act as TA's for intro to engineering and help with recruiting events
Targeted scholarships	Scholarships offered specifically for Black men at the institution; Black students in the college of engineering; Black woman in ME; Latina women in engineering; Black women in engineering; and 1st generation students in engineering	NACME grant for URM scholarships; Engineering diversity scholarships; "no-loan" grants for low income students at the institution; total cost of attendance scholarships for underrepresented students in engineering and CS	\$1 million in scholarships for Black engineering students	None specifically targeted to Black engineers.

## **Discussion and Future Work**

In this paper we have described the inputs at four colleges of engineering related to the MCCS model for student success [8]. This paper is not meant to represent an assessment of any of these programs, but to document the presence of programs, services, and activities that may influence Black student persistence in mechanical, electrical, and computer engineering. We described some services and activities that were also part of larger programs for completeness. We found that all of the universities contained significant elements of the framework. None of them offered all elements, which is to be expected as each institution and engineering student support center must make decisions on what is most needed for their student body within budget and personnel constraints. Some programs (e.g., LLCs) are limited in how many people they can serve while others (e.g., EE tutoring) serve all students, not just underrepresented ones. We were expansive in what we included in our search to ensure that we captured as many programs as possible that would benefit Black students in engineering, whether or not the programs or services were designed for them. We believe that such support programs, both targeted and otherwise, are necessary, but not sufficient, for fully addressing issues related to diversity in higher education. As one of our informants noted, in spite of decades of offering programs and activities to help Black and other underrepresented students live and learn in the predominantly White culture on his campus, the lived experience of Black students there has not changed much over that time. Rather, he hopes that these programs have empowered these students to cope better in the environment as it is.

This research is a first step in our analysis of student experiences and outcomes. We have begun by documenting the efforts made by our study institutions to help their Black students to be successful. We will continue to interview other key informants as appropriate on our study campuses as the study progresses. We also plan to interview 80 Black students who are currently majoring in or have switched from ME and ECE majors on these campuses to learn if and how these programs may have impacted them as well as what other factors they credit with their remaining in or leaving these majors. Our quantitative study will build on the analyses in [1] and [2], among other studies, while focusing on Black students at our study sites. In particular, the quantitative data will help examine the generalizability of themes emerging from interviews.

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