

WIP: How does it add up? Factors contributing to the academic success of mid-range engineering students

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This is a works-in-progress submission. In engineering, the expectation is that students often have a 3.0 GPA or above to be eligible for internships and scholarships and are on track for a career in the field. The present study seeks to examine how students can use forms of community cultural wealth [1] to enhance their engineering identity and self-efficacy and increase the support of community and resources to increase their GPA performance and persistence in engineering. Using an assets-based approach to examine how students achieve academic success, this study will examine the effect participation in an academic program aimed at student success had on mid-range first-year students. Specifically, this study will look at cumulative GPAs, academic standing, and program attendance to investigate whether active participation in the program improved students' cumulative GPAs. Mid-range students were initially targeted to receive an invitation to participate in this program that provided mentorship opportunities, career readiness strategies, and study skill strategies to see if it helped to improve their academic performance. This study defined mid-range as students earning a 2.5-2.99 cumulative GPA upon admission into the intervention program. Freeman [2] noted that Historically Black colleges and universities (HBCUs) offer nurturing and affirming environments that help students feel more academically motivated, aiding Black students' academic success. According to McGee [3], STEM environments are racialized environments for Students of Color. Thus, this preliminary study seeks to identify interventions that may help students develop a sense of belonging in STEM classes and the STEM workforce. The authors sought to answer the following question: If mid-range first- and second-year engineering students participate in an intervention program specifically designed to promote community, identity, and skills to seek support and resources, will their cumulative GPAs increase to a 3.0 by the end of their sophomore year? This study seeks to answer this question by reviewing aggregate data of first- and second-year engineering students who participated in a two year-long academic student success intervention program. This comparative quantitative study will compare their overall cumulative GPAs with engineering students who did not participate in the program. The program's participants attend the same institution, majoring in computer science, computer engineering, electrical engineering, mechanical engineering, bioengineering, or industrial and systems engineering. Results from this preliminary study will prompt conversations regarding best practices and interventions that may aid in student success for mid-range engineering students and will provide direction regarding future more comprehensive studies regarding this intervention program.

Introduction and Literature Review Overview

This is a works in progress submission. The National Science Foundation remarks that a diverse workforce is essential because bringing people together with different worldviews and experiences can help to unearth innovation and creativity [4]. While there has been an increase in the percentage of Black people (7%) earning bachelor's degrees in STEM majors, Black students are still trailing other students from other races in earning those degrees and Black adults are still underrepresented in the STEM field [6]. This fact is disturbing, given that there has been continuous growth since 2010 in the number of STEM graduates from U.S. colleges and universities [6]. In fact, the Journal of Blacks in Higher Education reports that Black people make up only 9% of the STEM labor force as of 2021 [5]. Thus, there is a need to increase the number of Black people in STEM fields. However, according to [3], STEM environments in higher education are racialized for Students of Color. Additionally, research [7, 8, 9] in higher education at Historically White Institutions (HWIs) regarding Black and Latino students' experience has revealed that Black and Latina women face oppression due to their race and gender. If Black and Latina women are facing unique challenges that are creating barriers to STEM degree attainment, this could indicate that Black and Latino males are also facing barriers. Thus, if there is a national push to increase the representation of Students of Color in the STEM field in America, attention must first be given to possible reasons contributing to them not pursuing and eventually earning STEM degrees.

Rainey [10] studied North Carolina college students from different institutions in the state and from various diverse backgrounds who were either current STEM majors or former STEM majors. Their study revealed that interpersonal relationships with faculty and peers and developing a science identity and the belief in one's competency in the STEM major were essential in helping build students' confidence to remain in the STEM major. Those participants that were not able to build those interpersonal relationships with others attributed that to being one of the top reasons why they left the STEM major [10]. Further research confirms the importance of students having a sense of belonging or identity within the STEM environment aiding students' persistence in their disciplines [11, 12, 13]. A connection between a sense of belonging and forming a science identity has also been noted as an integral component in aiding in the persistence of Students of color in their STEM disciplines [11]. When Students of color do not feel like they belong it may make them feel like they do not fit or belong within their STEM major, they may also feel like they cannot add value or contribute to the STEM field [11, 12]. Specifically, Campbell-Montalvo [12] found that Black students also tended to feel isolated if they did not see other students from their racial group represented in their programs. If Students of color feel isolated because they are the only one representing their gender and race [12] or like they cannot add value to the STEM field [11], it may impact how they view their fit in their program and can lead to attrition from the major. Hypervisibility due to the small number of Students of color pursuing STEM can also mean that those individuals endured negative racialized stereotyping in their STEM programs. McGee [15] noted that her Black and Latino participants endured racial microaggressions in their STEM education at their respective historically White institution (HWI), historically Black college or university (HBCU), and Hispanic-serving institutions (HSI) and it took a toll on their mental wellbeing. This indicates that regardless of the institution-type, the STEM environment itself may aid in perpetuating a hostile environment for Black and Latino students at a structural level as [3] posits. Mental

exhaustion can undoubtedly make Students of color feel like they do not fit within their programs, leading to their attrition from the major or worst, the institution. Thus, if recruitment of these groups is important and diversity of thought is integral in sparking innovation and creativity [1], then institutions must make an effort to nurture this diverse talent.

Freeman [2] noted that HBCUs offer nurturing and affirming environments that help students feel more academically motivated, aiding Black students' academic success. Thus, HBCUs may help to mitigate some of the racialized experiences Black students experience in their STEM disciplines. Perna [16] studied Black undergraduate women interested in STEM who attended the HBCU Spelman College. Perna [16] found that Black women thrived academically in STEM disciplines when they received initiatives such as access to undergraduate research opportunities and academic support services with programming designed to address the known academic challenges that may create obstacles to student success in STEM disciplines and they were able to have more interactions and encouragement from faculty. Like [16], this study will examine one HBCU's effort to intentionally provide a nurturing environment [2] and programming to help engineering first and second-year students with GPAs ranging from 2.5-2.99. Specifically, this preliminary study will investigate whether attendance and participation in an academic and student success intervention program that aims to cultivate a sense of belonging for Students of color, helped them in earning higher grades. The authors will use the results from this study to set up a more comprehensive mixed methods study to find out which specific elements of this program aided in their academic success.

This program takes place at a medium-sized HBCU in the southeastern part of the United States. As mentioned previously, research [11, 12, 13] confirmed the importance of a sense of belonging and community support in helping students to be successful in their disciplines. Yosso [1] looks at cultural wealth through the lens of critical race theory to center race and examines all the resources and ways of knowing that Communities of Color employ to aid in their success. Yosso [1] coins these various types of cultural capital collectively as community cultural wealth. Yosso [1] notes that community cultural wealth has six different types that Students of Color may bring to help them persist: aspirational, familial, social, linguistic, resistant, and navigational. As mentioned, like [1], other researchers found that Black students early exposure to STEM as well as family and community support aided in their interest and overall persistence in STEM disciplines [13, 14]. However, when students are away in college, they must find ways to build more community support by expanding their social and professional networks and by leveraging other types of community cultural wealth. In helping students cultivate their identities and sense of belonging and helping build their social and professional networks through programming, this intervention program hopes to help students to further cultivate and lean into these different cultural wealth types. In this study, the researchers sought to answer the following question: If mid-range first- and second-year engineering students participate in an intervention program specifically designed to promote community, identity, and skills to seek support and resources, will their cumulative GPAs increase to a 3.0 by the end of their sophomore year?

Program Description

This intervention program was created as an intervention for students earning between 2.5-2.99 as second semester first-year or first semester second year engineering students to help improve

their cumulative GPA to at least a 3.0 by the end of the sophomore year. First year students are defined as students entering college for the first time. Second year students are students that are still freshmen students by credit hours (under 30 credit hours), but that have been at the institution for a year. Students meeting the 2.5-2.99 profile by the end of their first year are invited to participate in the program by an email from the Dean of the College of Engineering after fall grades post. Thus, every new cohort begins every spring. If students are not interested in the program they do not have to respond to the email. If they are interested, they complete an application that contains questions to ask them how they believe the program will benefit them if selected. If students are not interested in participating in the program, they can notify the program's staff to be removed from the program communications. Once students are selected, they are notified by email to attend the orientation meeting to find out more about the program and the program's expectations for participants. The program requests that students attend at least four out of the six program sessions each semester. Additionally, the students are requested to meet with the academic coach assigned to work with the program to discuss their progress each semester. The academic coach monitors their grades and offers support, makes references to campus resources that may help them as they are navigating their academic journeys, and helps to facilitate other various administrative needs. The program has a program manager as well as a staff that creates the programming for the intervention and that evaluates the overall effectiveness of the program. Students are always requested to provide feedback on the effectiveness of the sessions and the overall programming by completing surveys. Each cohort has four semesters in the program.

Program outcomes

The program hopes to help students:

- develop their identity from the perspective of gender;
- increase self-awareness by acknowledging personal strengths and weaknesses;
- identify career and personal goals;
- demonstrate leadership skills;
- demonstrate abilities to maintain balance between academic and personal life;
- develop skills for academic and personal health and learn how to prioritize self-care;
- identify ways that social structures and public policies maintain an inequitable world for people with historically marginalized identities and learn how to combat those ideologies;
- expand their knowledge of and be able to identify resources and programs to address those concerns;
- learn how to effectively communicate, both written and oral; and
- acquire skills to develop meaningful, healthy relationships to sustain them through difficult times.

Program Session design

The sessions take place on either Wednesdays or Thursdays twice per month. If one week the session is on a Wednesday, then the next session happens on a Thursday. This meeting pattern enables students to be able to attend at least one session each month if they have night classes on one of the days. If students are unable to attend a session they are asked to email the program's coordinators. There is no real penalty for students not attending. The major tangible incentive in attending the sessions is that students are able to learn the skill being taught during the session. The major incentive to attending the one-on-one sessions with the academic coach is that

students receive added support (e.g. help with class scheduling, help with discussing academic decisions like whether to pursue a certain internship, or help with connecting to a needed campus resource) throughout the remainder of their academic journeys. Students also have the opportunity to apply to be an intern on the evaluation, social media or programming committees. Additionally, students are paired with a professional mentor in the engineering field during their first semester in the program. The session topics were created to help meet the outcome goals. Charts one and two lists the session topics:

CHART 1- SPRING SEMESTER/ YEAR 1 – PROGRAM SESSIONS

TEAM BUILDING
WHAT’S YOUR “WHY?”
TIME MANAGEMENT SKILLS
THE LEARNING AND STUDY STRATEGIES INVENTORY (LASSI) OVERVIEW OF RESULTS/REFLECTION
STUDY SKILLS |NETWORKING TIPS
GETTING PREPARED FOR INTERNSHIPS
READING FOR COMPREHENSION| ADVISING
ALUMNI PANEL – CAREER READINESS
GOAL SETTING AND WRAP UP/END OF THE SEMESTER CELEBRATION

CHART 2 - FALL SEMESTER/YEAR 1 – PROGRAM SESSIONS

WELCOME BACK |REFLECTIONS |REVISIT GOAL-SETTING| RESUMES & LINKEDIN
WHAT IS COMMUNITY-CENTERED SERVICE? | CAPSTONE IMPACT PROJECT PREP
ADVISING| GETTING PREPARED FOR INTERNSHIPS | MOCK INTERVIEWS
CAPSTONE IMPACT PROJECT PRESENTATIONS | GUEST SPEAKER
ALUMNI PANEL TOPIC: CAREER READINESS
GOAL SETTING | WRAP-UP/YEAR-END CELEBRATION

Methodology

Upon receiving approval from the Internal Review Board (IRB), participants were invited to complete a consent form to join the preliminary study of the intervention program. Due to the timing of the study the researchers were not able to collect testimonials that would have provided more context to program impact and helped to identify the most effective program activities; however, testimonials will be captured in future work and disseminations of the research. For this preliminary study, the authors also did not collect data regarding their immediate student feedback on sessions, however, future studies will assess student feedback regarding each session. The researchers compare the participants in Cohort one with Cohort two to first observe whether there are differences within the groups in terms of their starting, spring, and fall GPAs and their attendance in the program’s sessions. Cohort one students were invited to join the program at the end of the fall 2023 semester once they earned a GPA and thus began the program in spring 2023. Cohort two students were invited to join the program the following year, which began in the spring of 2024. The program's intake is every spring due to a stipulation request made by the program's company donors and the previous dean of the College of Engineering. The main goal of the intervention program is to catch students who have fallen into the mid-range and offer support to help them earn a 3.0 cumulative GPA by the end of their sophomore year. All the students in Cohort 2 have not yet reached sophomore classification, so this preliminary study will only look at the data from year one with both groups to allow the

researchers to make comparisons between both groups. In education, research tends to view Communities of Color through a deficit lens rather than an assets-based lens that honors and values what they bring to the table [15]. This preliminary study hopes to expand to a larger scale study that uses community cultural wealth [15] as its framework.

Results and Discussion

At first glance in Table 1, when comparing the GPAs, the participants from Cohort 1 ($n = 2.91$) started the program with a lower average GPA than the students in Cohort 2 ($n = 3.24$). All participants identified as People of color. Additionally, after being in the program for a semester, the average GPA for participants as a group in Cohort 1 had a slight drop in their GPA ($n = 2.90$) and a more drastic drop in their average cumulative GPA after their second semester of being in the program ($n=2.77$). As a group, Cohort 2 also had a drop in their average GPA ($n = 3.18$) after their first semester in the program and a more drastic drop in their average cumulative GPA after their second semester ($n = 2.71$). However, there could be other factors contributing to their GPAs dropping. For instance, students take more classes that are more of a review of high school during their first semester (e.g., English, Calculus I). The classes get more rigorous during the second semester, and they start having more technical classes. The point that these students persisted from semester one to semester two without withdrawing illustrates that something else motivates them to keep trying to achieve. Yosso [1] describes aspirational capital as maintaining one's hopes despite barriers. Participants may be using aspirational capital to help them persist from one semester to the next despite the increasing rigor of the curriculum. One of the sessions focuses on asking students to identify their “Why.” In asking students to identify their “Why” the intervention program is being intentional in helping student to remain grounded in their goals for their academic pursuits which aligns with the aspirational capital description [1].

Table 1

Combined Program Participant Profile* (n=11)			
	Average at Start of Program entry	First Semester of Program Average (Spring Cumulative GPA)	Second Semester of Program Average (Spring Cumulative GPA)
Cohort 1 (n=6) Entry spring 2023**	2.91	2.90	2.77
Cohort 2 (n=5) Entry spring 2024**	3.24	3.18	2.71

*Only includes data from the students that consented to allow their data to be used in the study

**This study follows the participants for one full cycle or year (spring to fall). Also, the program intakes in the spring of each year after students have earned a GPA.

Table two below shows the breakdown of the averages from Cohorts 1 and 2 and whether they participated in the program for four or more sessions. The request to participate in four or more sessions was an expectation expressed to the students when they agreed to participate in the program. Attendance is measured in this study because the authors are hoping to determine if the exposure to the content reviewed during the academic sessions is resulting in students earning higher GPAs. While the authors are not able to determine if participants found the sessions to be helpful without asking them directly, the authors can look at whether there could be a relationship between a Cohort's GPA and participation in the program. Cohort 1 had a higher average starting cumulative GPA ($n = 2.77$) than Cohort 2 ($n = 2.71$). As mentioned previously this study had more participants from Cohort 1 ($n = 6$) than Cohort 2 ($n = 5$). The additional starting GPA could have been high enough to slightly skew the starting average GPA.

Cohort 2 had a higher average attendance rate (100%) at the program sessions than Cohort 1 (83%). Additionally, Cohort 2 collectively had a higher spring average cumulative GPA ($n = 3.24$) than Cohort 2 ($n = 2.91$). Cohort 2 also had a higher average semester GPA ($n = 3.24$) than Cohort 1 ($n = 2.83$). Cohort 1 was the first iteration of the program at this institution and the program's coordinators collect survey information after each program to make improvements to the content. Thus, the programming may have been stronger for Cohort 2 than Cohort 1 and that may have contributed to the increase in average semester and cumulative GPAs for the students that opted to participate in this study. In the next phase of this study researchers will ask participants about the factors driving their attendance at the spring sessions.

Cohort 1 attended more program sessions (83%) than Cohort 2 (80%) during their fall second semester. However, Cohort 2 still had a higher average fall cumulative GPA ($n = 3.18$) than Cohort 1 ($n = 2.90$). Additionally, Cohort 2 also had a higher fall semester GPA ($n = 3.18$) than Cohort 1 ($n = 2.95$). Attending the sessions will help students further develop the community cultural wealth [1] that they already possess. In fact, the intervention program helps students to further cultivate their community cultural wealth [1] through the types of workshops and professional engagement opportunities it provides.

Yosso [1] defines navigational capital as being able to maneuver through institutions that may not have been created for Communities of Color. In having participants attend an alumni panel with professionals in their field discussing various topics like race relations and upward mobility, students are learning how to navigate the STEM workforce as a Person of color. This is essential not just in leveraging navigational capital, but also in building social capital. It is important for students to learn how to navigate STEM environments early since research has posited that STEM environments can be racialized for People of Color due to the STEM field itself being racist at a structural level [3]. Participants may also be cultivating resistant capital by attending the alumni panel since the alumni also share how they navigate racial politics in their departments and [1] defines it as gaining skills through resisting inequity. Additionally, in pairing participants with a peer and also a professional mentor and an academic coach familiar with their institution's academic policy they are able to also build and leverage navigational and social capital [1]. Finally, in having workshops that allow participants to express themselves authentically and by pairing them with other peers, the intervention program is also helping them to build and leverage their social capital.

Table 2

Cohort (n=6)	1
Starting Cumulative GPA (average of participants)	2.77
Spring 2023 Cumulative GPA	2.91
Spring 2023 Semester GPA	2.83
Fall 2023 Cumulative GPA	2.90
Fall 2023 Semester GPA	2.95
Spring 2023 Attendance Average (for those that attended 4 out of the 6 sessions)	83%
Fall 2023 Attendance Average (for those that attended 4 out of the 6 sessions)	83%
Cohort (n= 5)	2
Starting Cumulative GPA	2.71
Spring 2024 Cumulative GPA	3.24
Spring 2024 Semester GPA	3.24
Fall 2024 Cumulative GPA	3.18
Fall 2024 Semester GPA	3.18
Spring 2024 Attendance Average (Attended 4 out of the 6 sessions)	100%
Fall 2024 Attendance Average (Attended 4 out of the 6 sessions)	80%

Starting cumulative GPA was collected at the end of the fall semester 2022 for Cohort 1 and at the end of the fall semester 2023 for Cohort 2.

*For this study complete participation was marked as attending at least four out of the six sessions.

Thus, it is imperative that students in the program attend the sessions because there are very intentional opportunities for them to fully cultivate and harness all the aspects of their community cultural wealth while they are in college as preparation for the STEM workforce. While the program aims to help improve cumulative GPAs to 3.0, semester GPAs contribute to the cumulative GPA. Cohort 1 participants on average did not improve their cumulative GPAs to a 3.0 at the end of their first year in the program. However, Cohort 1 participants on average did see some improvement from their spring ($n = 2.83$) to their fall ($n = 2.95$) semester GPAs. This indicates that the program could be having an impact in other ways. Socialization [13] and helping to create a sense of belonging can impact fit [12] which can lead to persistence in major [10] and graduation. Thus, this intervention program's intentional focus on these areas and others may be contributing at least in part to the participants' persistence in their majors. The increase in participants' fall semester GPAs for both groups is important to note because it shows that students are able to keep up with the rigor of their program (i.e., classes get harder as students move into their sophomore year). These results illustrate that the program could be helping students improve. Additionally, the lower fall semester and cumulative GPAs for Cohort 2 when compared to their performance in their initial spring semester is also important to note because while classes are increasing in rigor, they are still maintaining at or above a 3.0 GPA, which may be in some part be due to their participation in other aspects of the intervention program as number of times students met with their academic coach, or peer or professional mentors, program assistants, was not measured in this study.

Limitations

This preliminary study has a very small sample size ($n=11$) and that is a major limitation. By only looking at GPAs, academic standing, and program attendance the researchers do not have more context into which features of the program are aiding in the participants' academic success. However, the researchers were able to note basic trends between the two cohorts and the trends within each cohort from first to second semester. Also, the students that opted out of the study may have had higher GPAs by the end of their second semester in the program, thus the current sample size may be skewed by lower or higher GPAs that are not as representative of the larger group. While this preliminary study may not be generalizable to the larger group of engineering students, it does help the researchers to note the patterns between earned cumulative GPAs and program attendance. This helps the researchers to think of how to scale up this study using either a mixed method or qualitative research design to investigate further. Finally, the researchers did not incentivize participation in this study and the consent forms were given at the end of the semester when students were about to begin their exams which could explain the lack of participation.

Future Works

While the results of this preliminary study do not seem to show that program attendance is helping to improve participants' cumulative GPAs drastically, it does show that many of them are seeing some improvement and, even more importantly, they are remaining in good academic standing, and they are staying in the major. Rainey and colleagues [10] found that students who remained in their STEM major reported feeling more of a sense of belonging than those who left the major. If the researchers do a follow-up qualitative study, it may also reveal that the students in this program are also attributing a sense of belonging and bonding with their other engineering students as contributors to their overall success. A follow-up qualitative study may also reveal that even more of them are finding value in other specific elements of the program, such as having the opportunity to become an intern with the program and being paired with a professional mentor or building their social network even though their cumulative GPAs may not be significantly improving. This could be an important finding because if many students find value in certain program features, it may signal the need to scale up those programming parts to provide access to more students in the college overall. Thus, the researchers hope to extend this study by examining how participants use their community's cultural wealth [1] to aid their success and how the program helps them hone those skills. The researchers also hope to extend this research by identifying the types of community cultural wealth [1] that students name as contributors to their persistence through their rigorous engineering curriculum. The program aims to help students improve their cumulative GPA to a 3.0, which makes the case that a 3.0 is the marker of success. However, people measure success differently. Thus, a qualitative study would also help the researchers to understand how the participants view success. Finally, the researchers may opt to conduct a mixed methods study incorporating a questionnaire with more participants and one-on-one interviews as this may also help to add more context and richness to this preliminary study's findings while also helping to make the results more generalizable to all engineering students.

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