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WIP: Assessing Engineering State of Mind of First-Year Undergraduate African American/Black Students in Scholar Programs

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Assessing Engineering State of Mind of First Year Undergraduate African American/Black Students in Scholar Programs (Work-in-Progress)

Abstract

Research shows there are various internal and external influences that contribute to student's enrollment and retention in engineering programs, especially minority engineering students. As a result, these factors can impact a student's engineering mindset and, in turn, retention in a program. In this work-in-progress study, an examination of first year African American/Black undergraduate students' state of mind was evaluated at the University of Maryland, Baltimore County (UMBC) over the course of the students' first semester in Fall 2020. Students in this population are currently enrolled in engineering 101, virtually, their first course in engineering. Additionally, UMBC houses well-known scholar programs that support 15% of the first-year engineering students. Through these programs, students receive guidance and support to students throughout their tenure at the university.

Using a mix-method assessment, students were initially asked to participate in the Engineering State of Mind Instrument (ESMI), a recently tested and developed tool, at UMBC. The ESMI provides immediate evaluation to the student, assisting them in understanding their attitudes, perceptions, motivations, and self-efficacy in pursuing an engineering degree. Students can use the results and recommended interventions to improve any mindset deficiencies. African American/Black students, who participated in the instrument, were asked to engage in a follow-up interview providing a more detailed explanation of their current mindset about the engineering field. Additionally, scholar affiliated and non-affiliated programmed students were classified for further comparison of the programmatic impact. While conducting the interview, a series of questions were included regarding the intersection between virtual learning and belonging within the engineering community.

At the end of the Fall semester, this data was analyzed finding significant correlations and themes regarding a student's engineering state of mind, motivation to persist through a program, and belonging within the engineering community. This also highlights the impact of the current virtual learning environment. In this paper, the preliminary data in research will be used to help inform the impact and role that scholar programs have on African American students in their first year of engineering.

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Introduction

In the United States, there continues to be a "persistent underrepresentation of low-income, first-generation, and underrepresented minority students among those who complete an undergraduate degree in STEM (science, technology, engineering, and mathematics)" [1]. Research studies have shown that students who participate in STEM intervention programs are more likely than students with similar academic backgrounds to maintain an interest in STEM, earn good grades, complete their degrees, and attend graduate school [1]. In 2018, Black students obtained only 4.2 percent of the bachelor's degrees awarded in STEM fields [2].

As of Fall 2020, approximately 240 students were enrolled virtually into their first-year engineering course, Engineering 101 (ENES 101), at UMBC. Of those 240 students, about 40% identify as African American/Black with 15% of those students a part of or affiliated with a Scholars Program, leaving 25% of students non-programmed [3]. Scholars Programs are unique to UMBC and provide both monetary and academic support. This research will aid in understanding the experiences of African American/Black students who are programmed versus non-programmed in order to examine what specific components are necessary to improve engineering students' academic mindsets, increase minority-student STEM retention, and foster inclusivity of underrepresented students in engineering. A critical component of this research is examining the intersection of how the current virtual learning environment and pre-existing factors impact a student's engineering state of mind. Ultimately, this research will provide a deeper understanding of the correlation between student support and belonging within their respective engineering discipline.

The specific pre-defined aims or research objectives of this project are:

1. Understanding how a student affiliated or non-affiliated with a scholar program can impact a student's engineering mindset and motivation to persist within an engineering discipline.

2. Examine and understand the correlation between a virtual learning environment and the effect it has on a student's sense of belonging in the engineering community and understanding of engineering content.

3. Identify the major elements that propel the motivation and impact the engineering mindsets of African American students pursuing engineering degrees at the University of Maryland, Baltimore County.

Motivation

The primary aim of this research was to understand the intrinsic and extrinsic factors, with an emphasis on scholars' programs, that impact Black students' retention and success in engineering disciplines. In 2019, Dr. Jamie Gurganus at the University of Maryland, Baltimore County conducted a study using a novel instrument that helped engineering students in their first year understand their existing motivations, self-efficacy, and emotional states in pursuing engineering [3]. These students were then dissected into various subgroups such as ethnic background, scholar program, and race to analyze their individual pre- and post-emotional state assessment scores.

Of the data obtained from the assessment, the Social Cognitive Career Theory (SCCT), was used as the framework to develop the Engineering State of Mind Instrument (ESMI). Contributing variables to emotional states of students, such as feelings of inclusion, coping self-efficacy, and engineering career success expectations were examined [3]. Data from this study revealed that students from underrepresented groups such as the Black, Latinx, and American Indian populations feel less included in their engineering classes, in comparison to the majority groups. A similar trend was identified in the overall emotional states and engineering career success expectations of the underrepresented population as well.

In addition, Gurganus' study examined how program affiliation can impact a student's emotional state in their first year in an engineering program. When assessing scholar programs, students who associated with a scholar program had a higher feeling of inclusion. Meyerhoff Scholar Program, a nationally known African American/Black PhD producing collaborative, constantly ranked high in all emotional states while other programs were not as consistent. However, the non-programmed students ranked low in the majority of the categories especially in terms of their inclusion within the engineering community.

From this research, several significant themes were identified. One in particular, showed that scholars' programs have a great impact on the emotional states of engineering students. In addition, there are clear elements of certain programs that have a stronger impact than other programs in the development of students in their first-year engineering program. Both identifying and understanding how these elements can be replicated or used will help students who are not affiliated with programs, improve current programming, and most importantly help students from underrepresented groups to be more successful in their respective engineering disciplines.

After this study was conducted, it appealed to a new principal investigator to further examine and understand the African American/Black subsection of the research, specifically looking at those who are in scholar programs compared to non-programmed students. The objective was to identify the key support structures and resources affiliated with the scholar programs in order to determine how those can be replicated for students who are not affiliated (or non-programmed) in order to improve students' engineering trajectory.

The principal investigator of this research is a Black first- generation college student pursuing an engineering degree, and part of a scholar program at UMBC. However, the

investigator had a poor first year experience, due to initial struggles both academically and socially at the university. They wanted to understand how these factors as well as others affect the first experience of African American/Black students' engineering mindsets, trajectory, overall experience, and success. Due to COVID-19, the investigator also wanted to understand the intersection of a virtual learning environment's impact on these students' belonging and engineering mindsets.

Research Methodology

Using a mix-method assessment, students were initially asked to participate by taking the Engineering State of Mind Instrument (ESMI) with Internal Review Board approval. The Engineering State of Mind Instrument was developed from 2011 to 2019 by Dr. Gurganus. Using the Qualtrics Survey online software, algorithms were created to calculate results consisting of the 17 variable measures and providing immediate feedback to the user. The scores were summed, scaled, and normalized using Statistical Package for the Social Sciences (SPSS) [3,4].

To provide the users a further understanding of their assessments, engineered.umbc.edu was developed. Based on the SCCT, each variable was explained to the user to ensure that they understand the meaning behind their score [2]. In addition, recommendations were provided to the user including information about mentoring programs, advising, and organizations.

Students were asked to complete the ESMI via the website. This link was added to an email that was sent out to the students regarding the research study being conducted and information on the ESMI. The ESMI provides immediate evaluation to the student, assisting them in understanding their attitudes, perceptions, motivations, and self-efficacy in pursuing an engineering degree.

For this study, modifications were made to the ESMI, adding demographic and background questions for students to answer. This targeted what engineering experience and influences they had prior to entering college, their ENES 101 class section, and the student's intended engineering major. After the instrument was administered, the data was evaluated using the IBM SPSS software to identify themes, patterns, and to create graphs representative of the data.

African American/Black students, who participated in the instrument, were asked to engage in a follow-up interview providing more detail of their current mindset about the engineering field. IRB approval was received prior to engaging with the students. Additionally, scholar affiliated and non-affiliated programmed students were classified for further comparison of the programmatic impact. Once the student confirmed that they were interested in participating in the interview, they were sent a consent form prior to the start of the interview.

While conducting the interview, a series of questions was included regarding the intersection between virtual learning and belonging within the engineering community. In addition, questions were asked about the student's foundation in engineering, internal and external factors that have impacted their decision to pursue engineering, motivation to persist,

and how they feel they belong among their peers and the engineering community. These interviews were conducted using Google Meet, were recorded (with consent), and transcribed.

Results and Discussion

Quantitative Analysis: Engineering State of Mind Instrument

About 35% of the students enrolled in the Engineering 101 (ENES 101) course in the Fall of 2020 at UMBC identified as African American/Black. There was a total of 53 students, from Engineering 101 (ENES 101) who participated in the instrument. From this population, 15 individuals self-identified as African American/Black students. Students were separated into two categories, those affiliated with a scholar's program and those with no scholar's program affiliation.

In the proceeding section, the data from the instrument is shown and broken into sections using the SCCT constructs; social persuasion and vicarious experiences (SPVE), mastery experiences (ME), and emotional states. Each section was tested for normality using the Shapiro Wilkes test because of the small sample size. All the variables were shown to be normally distributed.

Social Persuasion Vicarious Experiences

The percent mean data revealed that African American/Black students who were non-programmed had a primary financial motivation for pursuing a degree in engineering at 79% as shown in Table 1.

Table 1: Social Persuasion Vicarious Experiences Variable Results for Each Study Group

Variables	Non-Programing Students	Programing Students
Financial Rewards	79%	67%
Intrinsic Behavioral	72%	89%
Intrinsic Psychological	71%	89%
Social Good	67%	52%
Mentor Influence	37%	18%
General Impressions of Engineering	71%	86%
Parental Influence	10%	---*
Overall SPVE	58%	57%

**No data to report due to insufficient response*

However, these students were also motivated by building and design. This was revealed in the Intrinsic Behavioral score of 72%, and Intrinsic Psychological of 71% that showed these students enjoyed doing engineering for the sake of its field. They value the Social Good of engineering at 67%. Mentor and Parental Influence ranked among the lowest at 37% and 10%, respectively.

Scholars program affiliated students were primarily motivated to pursue engineering for the Intrinsic Behavioral and Psychological factors. Financial Rewards were at 67%, and Social Good at 52%. Mentor Influence ranked among the lowest at 18%. Both groups had a high motivation toward their General Impressions of Engineering. Programmed students had a higher General Impression of Engineering at 86%, whereas non-programmed students ranked at 71%. This could be due to the fact that scholar programs provide more resources regarding information on different engineering disciplines, career outlook, and overall impression on the requirements and opportunities within engineering.

Both groups expressed that Mentor Influence was among their lowest motivational factors. Primary motivations varied between the groups showing that students who are affiliated with a program demonstrate more intrinsic influences, or motivations within themselves or commitment to a goal, that impacts their decision and desire to pursue engineering whereas non-programmed students have more external impacts to pursue engineering. To further understand the motivation variation between the groups, interviews were conducted and assessed. However, it is clear that mentor influence was not a strong motivational factor for either population.

Mastery Experiences

First year African American/Black engineering students in both groups exhibited a high Perceived Importance of Math and Science Skills, at 89%, in order to be successful as an engineer (Table 2).

Table 2: Mastery Experiences Variable Results for Each Study Group

Variables	**Non-Programing Students**	**Programing Students**
Perceived Importance of Math and Science Skills	89%	89%
Perceived Importance of Professional and Interpersonal Skills	76%	80%
Overall Mastery Skills	83%	84%

This is an important aspect because math and science and professional and interpersonal skills are essential in the success of an engineer. However, when the Perceived Importance of Professional and Interpersonal Skills variables was examined, programmed students showed a to

value this skill set more at 80%. Whereas non-programmed students had a perceived importance of 76%. This difference could be attributed to students' holistic impressions of what is needed for them to excel in engineering. Non-programmed students lack in the opportunities programmed students receive (i.e., mentorship, career exploration, guest speakers etc.). These external influences provide a unique lens enhancing the students' understanding of the need for these engineering skills.

Emotional States

The participant's Emotional States were low in both programmed and non-programmed students, especially in feelings of inclusion. Students who are programmed have lower, non-significant, engineering career success expectations than non-programmed students with about a 11% difference as shown in Table 3.

Table 3: Emotional States Variable Results for Each Study Group

Variables	**Non-Programing Students**	**Programing Students**
Feelings of Inclusion	56%	57%
Coping Self-Efficacy	71%	68%
Engineering Career Success Expectations	77%	66%
Overall Emotional States	68%	64%

Programmed students are encouraged by their scholar programs to pursue engineering-based research instead of industry. Potential misunderstanding and expectations of the engineering research, low research self-efficacy, may contribute to the uncertainty leading them to feel they are unable to be successful in the field. However, the virtual environment caused both groups to have lower than expected engineering emotional states. Reflecting on the Social Persuasion Vicarious Experiences results, the motivation to pursue engineering for the financial rewards ranked the highest in the non-programmed students. These students may attribute success in engineering to earning a comfortable salary, which attributes to having a stronger engineering career success expectation. Future examination of the population would provide a more defined conclusion.

Non-programmed students had a slightly higher coping self-efficacy at 71% than programmed students at 68%. Due to the virtual learning environment, most of the students were feeling isolated and less engaged. These low emotional states are likely to impact their motivations to persist in engineering.

Comparison of Means One-way ANOVA

The percent mean comparisons of the programmed and non-programmed students in each SCCT category were utilized to identify possible correlations between data sets. However, an additional one-way anova analyses were conducted to determine the significance between the programmed and non-programmed students within the three major categories. Each variable within the three categories was assessed at 95% confidence interval level.

Analysis results from Table 4 showed no statistically significant difference between the programmed and non-programmed students for each of the respective variables examined in the social persuasion and vicarious experiences.

Table 4: Comparison of Means One-way ANOVA Results for Social Persuasion and Vicarious Experiences

Social Persuasion and Vicarious Experiences (SPVE) Variable	**Significance ($p < 0.05$) ***
Financial Motivation	0.857
Parental Influence	----**
Social Good	0.254
Mentor Influence	0.788
Intrinsic Psychological	0.162
Intrinsic Behavioral	0.589
General Impressions of Engineering	0.070
Overall SPVE Value	0.643

*Note: *Data was assessed at a 95% confidence interval ($p<.05$).*
***One group did not report and therefore was included in the analysis.*

Calculated results from Table 5 revealed that the mastery experiences category and variables did not have a statistically significant difference between the programmed and non-programmed students as well. Additionally, Table 6 possessed a similar trend with no significant difference between the two groups within the emotional states' category and the variables. While the overall quantitative data does not reveal a significant difference, further analysis was conducted through qualitative interviews to gain more insight from each of these groups.

Table 5: Comparison of Means One-way ANOVA Results for Mastery Experiences

Mastery Experience Variable	**Significance ($p < 0.05$)**

Perceived Importance of Professional and Interpersonal Skills	0.695
Perceived Importance of Math and Science Skills	0.835
Overall Mastery Experience Value	0.888

Table 6: Comparison of Means One-way ANOVA Results for Emotional States

Emotional States Variable	**Significance ($p < 0.05$)**
Feelings of Inclusion	0.752
Coping Self-Efficacy	0.655
Engineering Career Expectations	0.688
Overall Emotional States Value	0.744

Qualitative Analysis: Post Engineering State of Mind Instrument Survey Interviews

In the qualitative portion of the research, students who participated in the ESMI and identified as African American/Black were asked to participate in an interview regarding their ESMI results. Additionally, questions regarding the virtual learning environment impacting their first-year engineering experience were investigated. Common themes were identified among the non-programmed students and programmed students that supported the pre-defined research objectives. The themes are categorized as they relate to each predefined aim. Quotes from students are provided as examples to support each theme. While several themes were identified, the most common responses reflected the following:

- Common Themes Among Both Groups:
    - Feelings of isolation due to lack of community – AIM #1 & #2
    - Difficulty retaining engineering content – AIM #2 & #3

- Non-Programmed Students:
    - Struggling with the decision to continue pursuit of respective engineering discipline- AIM #1 & #3
    - Strong mentor and familial influence – AIM #3

- Programmed Students:
    - Strong sense of collegiate preparedness- AIM #1 & #3
    - High intrinsic psychological and behavioral motivation – AIM #3

Common Themes Among Both Groups:

Feelings of isolation due to lack of community - AIM #1 & 2

Students from the programmed and non-programmed groups both felt isolated due to the virtual learning environment. Being online, they felt a disconnect between students in their courses and the greater UMBC community. Without the opportunity to engage in person, students struggled finding peers to work outside classroom time. Despite being in a scholar program, one of the African American male-programmed students explained the difficulty in building community in the Fall 2020, due to being at home instead of campus:

..... Fall Semester and Spring Semester have been different because Fall Semester I [was] completely virtual at home, but this Spring Semester I am actually on campus. In Fall Semester I mostly worked by myself because it was difficult to develop a study group. But this spring I have been able to collaborate and work with other people face to face while still following COVID-19 guidelines. It has actually been really helpful in terms of finding a study group and bouncing ideas off of people because it is hard to do this alone.

Another example was an African American female non-programmed student who, at the time, was living out of the country.

…… It was very difficult to connect with people like we had class group chats, but even when they are active because of the time difference. It's hard to even be online at the same time as other people, like by the time it's almost evening for me it's pretty early in the morning there. I think about 10:00 AM in Maryland [and] about 5:00 or 6:00 PM my time.

So even having my classes so late, I was always tired and whenever I was done with classes I just wanted to sleep but that was when all peers were just starting to get active on all that group chats and such. It was very difficult to like, make friends or connect with people.

Difficulty retaining engineering content- AIM #2 & #3

Although many of the students took virtual classes prior to entering UMBC, they found it more difficult to grasp the engineering content due to lack of group collaboration or the inability to navigate academic help resources. For example, a non-programmed student explained her challenges in the virtual environment:

…. I'm a very hands-on learner. I need to be there in person, ask questions why, and just see it done. Virtual [learning] is a little more work in a sense, so you have the lecture but because it is virtual, and I am staring at a screen the information is not absorbed all the way. But if it was in person then I would not have to spend like an extra like 4 hours a week just trying to understand what was taught.

Common Themes Among Non-Programmed Students:

Struggling with the decision to continue pursuit of respective engineering discipline- AIM #1 & #3

The non-programmed students explained, during the interview, their uncertainty to continue in engineering. Each student displayed a high level of doubt and low confidence regarding their future pursuits in engineering. For example, one female student explained her struggle with determining what specific engineering disciple would be best in preparation of a career in biomedical engineering:

..... I'm currently talking with the people in the Individualized Study Program because when I first came to UMBC, I wanted to do biomedical engineering to focus on learning how machines interact with the human body. I want a nice way to combine both medicine and engineering at the same time. I am not really sure [of the] best classes to take, and it makes it difficult because I cannot make my own major until my junior year. I am just a little confused because I do not want to take the wrong classes. I do not want to move completely to chemical engineering and then find out I have to take some mechanical engineering classes or vice versa. I just don't know.

Another example of this theme was one student's idea of engineering and their inability to connect to the content. This decreased their desire to continue in any engineering field. The student explained their self-discovery after taking the ENES 101 course and the ESMI:

..... I am currently a chemical engineering major, but I am not sure at the moment if engineering is really for me. The ESMI helped me to see that maybe I'm not interested in engineering but STEM. I am more interested in just the purely science portion. Well, at the moment I really don't see myself remaining as an engineering major. Even the introduction to engineering class this Fall Semester, it wasn't difficult per say but I didn't enjoy it at all. It was like one of my least favorite classes. I liked the professors, but I just wasn't interested in any of the material at all. So, I figured that if I can't even enjoy or have interest in engineering right now, it's not likely to get any easier.

Strong mentor and familial influence- AIM #3

Assessment from the ESMI revealed mentor and parental influence were ranked as the lower motivational reasons for a non-programmed student's desire to pursue engineering. However, the interviews revealed some type of familial influence on a student's desire to pursue engineering. For example, one student expressed how the encouragement from their uncle contributed to their interest in obtaining engineering degree:

... Well, I'd say probably the most prominent influence was my uncle. He's always been really invested in my education because he does not have any children of his own. I mentioned to him when I was about thirteen that I thought that I might like engineering and ever since then he's always talking about how he has this plan that maybe I'd come to work with him after I graduated. My father was pretty absent. He was like the closest thing I had to one, so I guess as time went on, even though I had my doubts that maybe engineering wasn't for me. I felt like if I did anything different, I would be disappointing him.

Another example was a female's student physics teacher and step coach in high school that encouraged her to pursue a STEM degree. They also served as a mentor in the college application process when declaring her respective major:

…. I took Physics my freshman year, and then took AP Physics B my junior, and then took AP Physics C my senior year. I had a pretty close relationship with my physics teacher, and I loved the class. It was a class that I did pretty well in. My love for physics really made me want to go into physics and engineering. I am also pretty sure that it was because of my physics teacher why I decided to pursue engineering. In high school, I was on the step team throughout my years, and my step coach really served as a mentor. She helped me with applying to colleges and choosing a major and a minor. My parents were not really much help with that.

Common Themes Among Programmed Students:

<u>Strong sense of collegiate preparedness- AIM #1 & #3</u>

At UMBC, some scholar programs hold summer orientations and sessions to prepare students for the transition from high school to college. One male student described his experience and the benefits of participation in his scholar program's summer transition program:

…. Also, because Meyerhoff had the Summer Bridge Program, and it wasn't in person it helped me to prepare for the upcoming virtual semester. [Activities and classes] for that were virtual, it was really tough because it was having to wake up at 6:00 AM and get on your laptop and be on it throughout the whole day. So, I guess that program got me ready for being virtual in the fall. So, it was a win, like when I did [begin the semester] a lot of the stuff I had already done in Summer Bridge, I was prepared for. Summer Bridge was difficult, but it was good in that aspect. I wasn't caught off guard, but some people might be by the virtual aspect of things.

<u>High intrinsic psychological and behavioral motivation – AIM #3</u>

Intrinsic motivation is defined as one's internal drive to accomplish a task or goal. Programmed students ranked Intrinsic Psychological and Behavioral motivation, at 89%, which was the highest in the SPVE category. One student described how his childhood interest in cars developed into his passion to pursue mechanical engineering:

……I had to ask myself, you know why am I doing this? Really thinking about that and taking the ESMI survey really helps you figure things out or just like, set in stone that you know what you're doing. You are doing what you really want to do. I set in stone at an early age that I wanted to be a mechanical engineer because I liked cars and my mom said that was good for me and then you know, as you grow up you know you think to yourself is this something you still want to do, or do you want to do something else? And then I went through ENES 101 and I knew that mechanical engineering was actually something I wanted to do. This is something that can lead to other things. It's a good foundation.

Limitations

There were quite a few limitations to this research study. One of the major limitations was the lack of African American/Black ENES 101 students' response and completion of the Engineering State of Mind Instrument. Out of a total of 53 survey responses, only 28% self-identified as African American/Black students. Additionally, of those students that participated, only a few were willing to provide contact information for a follow-up interview. As a common problem in many engineering education studies, the female to male ESMI participant ratio was low, in both the qualitative and quantitative portion of this study. This limitation must be considered as it could yield bias results. Future work will include advocating to specific groups to participate in the research and providing some type of reward or compensation. Additionally, this research study does not include transfer students who are entering into their first-year engineering disciplines at UMBC. A separate instrument is currently being developed and tested that will aid non-traditional first year students entering UMBC. Adding transfer students to this study will provide different viewpoints on student experiences, engineering mindsets, and overall trajectory.

Conclusion and Future Work

From this study, it was evident that African American/Black students benefited from understanding their Engineering State of Mind results. Students being involved in engineering courses alone do not provide a strong sense of community, belonging, and success especially in the current virtual learning environment. Data revealed that there were no significant differences between non-programmed and programmed students in all the variables (Table 2, 3,4) including Social Persuasion Vicarious Experiences (SPVE), Mastery Experiences (ME), and Emotional Psychological State.

Of the first year African American/Black engineering students that participated in the instrument, all exhibited low feelings of inclusion. This was highly related to lack of community or engagement with other students. The primary motivation for non-programmed students was financial reward. Programmed students were motivated by their own intrinsic psychological and behavioral motivation. This clear motivational difference shows the value of how a program can help nurture a student's motivations beyond the financial gains.

The virtual learning environment impacted all of the African American/Black students' engineering educational experiences. This challenge led to no significant differences shown between programmed and non-programmed students within the examined variables. Future work will encompass comparing the African American/Black population to other ethnic groups. Additionally, a pre and post assessment utilizing the Engineering State of Mind Instrument will be utilized for all groups in order to determine the overall change in students from the beginning to end of a semester. Moreover, this could provide more significance in the data and allow for a greater range of comparisons among different groups.

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