

PhD'ing While Black: Unpacking the Emotions of Navigating Engineering as a Black Student and the Implications for Mental Health

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Mental health has become an emergent issue across the United States, especially with respect to graduate students. Graduate students are often faced with a wide variety of academic, professional, and personal challenges across their academic journeys that can impact their persistence in their graduate programs. These challenges are often exacerbated when racialized aspects of identity are introduced/considered/threatened. Black graduate students in engineering deal with additional scrutiny, such as microaggressions, racism, and other racialized experiences throughout their journey. This results in a wide variety of psychological and behavioral responses unique to this group, such as feelings of powerlessness, invisibility, loss of integrity, pressure to represent one's group [1], anger, escapism, withdrawal frustration and avoidance [2]. In their study of graduate student mental health, Hyun, Quinn, Madon, and Lustig demonstrated that many graduate students express negative emotional responses to stress that impact their wellbeing and academic performance [3]. Emotions describe a person's internal state as expressed by physical or sensory feelings and are reactions to meaningful encounters that occur in an individual's life [4]. In a study of over 200 graduate students, Gloria and Steinhardt found that there was a correlation between positive emotions and heightened levels of resilience, both directly and indirectly through development of healthy and effective coping mechanisms [5]. However, a combination of stereotype threat, and racialized stress associated with Black graduate students navigating engineering spaces can cause a higher volume of negative emotions such as frustration and anxiety [6]. And yet, while there are many studies linking the graduate experience to mental health, very few explicitly disaggregate the unique emotional experiences of Black engineering graduate students. Insight into the emotions endured through the lived experiences of Black students could elucidate specific stressors proactively and influence efforts to mitigate further mental health concerns and improve motivation to continue in these programs by encouraging a higher frequency of positive emotions. An intentional focus on issues impacting emotional responses and mental health and support may prove to be an effective way of fostering greater participation of Black students in engineering graduate studies.

The purpose of this study is to understand the stressors that Black graduate students encounter in engineering and the emotions associated with those experiences. This study is affiliated with a National Science Foundation (NSF) study investigating the role of engaging in professional organizations—such as the National Society of Black Engineers (NSBE) and Black Greek Letter Organizations (BGLOs)—and the mechanisms by which they promote support for Black engineering students. Through the data collected, it was found that emotions played a large role in the responses, perceptions, and actions of the Black graduate engineering students interviewed; hence, this work addresses the following research question: How do Black graduate students emotionally experience navigating engineering in academia?

Background

Increasingly, researchers are acknowledging the fact that emotions and their affects are “of critical importance for student's academic learning, achievement, personality development and health” [7] [8]. Emotions can have a profound effect on a student's engagement within academic

spaces due to the physical, cognitive, and expressive reactions that occur as a result of certain feelings. Clore & Huntsinger explored the affective influences, defined as the direct responses to the emotions presented, on cognitive processes associated with learning depending on the mood of the individual. Areas effected include perception, attention, social judgement, cognitive problem-solving, decision-making and memory processes [9]. Social emotions, or emotions related or directed towards other persons, have been found to directly impact how students engage with academic tasks [10]. This is exacerbated in traditional teacher-student situations as well as peer-to-peer situations, which can ultimately cause these students to steer away from academic-centered interactions [10]. This type of disengagement could be paramount in the social and academic integration issues often found within Black engineering students. Emotions can play an integral part in the experiences that Black graduate students will have navigating engineering environments, especially amongst the racialized barriers that are faced.

Racialized experiences for Black students are well known to be commonplace in engineering due to the unique challenges they face with respect to developing an engineering identity and a sense of belonging [11]. Weathering, a term originally coined by Geronimus, Hicken, Keene and Bound, and later adopted by McGee and Stoval, deals with the long term effects (physical, emotional and psychological) of dealing with a society in which racial barriers are systemic, and characterized by white dominance and privilege [12] [13]. According to McGee, “Weathering severely challenges and threatens a person’s health and ability to respond in a healthy manner to their environment,” touting consequences such as increased likelihood of illness, psychological issues, and advanced aging [13], [12]. Weathering is an example of how sustained negative emotional responses to racialized experiences can have long standing effects on Black engineering students.

Given that engineering is a majority white field, weathering can be a common occurrence for Black engineering students. Emotions will likely play a significant role in the responses these students have while navigating engineering. Whether the internal reaction to a racialized experience is positive or negative, and the expression of the emotion is outward or inward, these emotions will take up cognitive resources as the Black student makes sense of the situation and what just happened to them [14]. This leads to non-task-related thoughts, making it more difficult to focus. The prolonged exposure to weathering can result in negative consequences such as racial battle fatigue. Racial battle fatigue addresses the constant use of psychological, cognitive, and emotional resources to cope with the prevalence of racialized experiences such as microaggressions, macroaggressions, and prejudice [15]. Black students, especially in engineering deal with situations that are very emotionally taxing; therefore, it further reinforces the fact that it is necessary to explore and address the emotions experienced by Black students as they navigate their respective engineering environments.

Theoretical Framework

This work will adapt the framework of Linnenbrick-Garcia and Pekrun’s Circumplex Model of Affect, where emotions are categorized according to the intersection of affect and activation [7]. Affective states or dimensions of valence are considered to be emotions or moods and can be described as positive and pleasant or as negative and unpleasant. Activation refers to energy or

stimulation and can be expressed cognitively and/or physiologically. For example, the high activation and negative emotion of anger can cognitively impact someone's ability to focus and the physically they may feel their chest tighten [16].

The application of the Circumplex Model of Affect provides insight to the valence and activation of emotions and their responses that Black graduate students experience while navigating in the predominately White environment of engineering. Situated in knowledge that high-activation, negative emotions contribute to cognitive overload, which impacts mental health, learning more about experiences encountered by Black students navigating engineering and their associated emotions could add to our understanding of macrolevel responsibilities for their success such as structures, policies and supports.

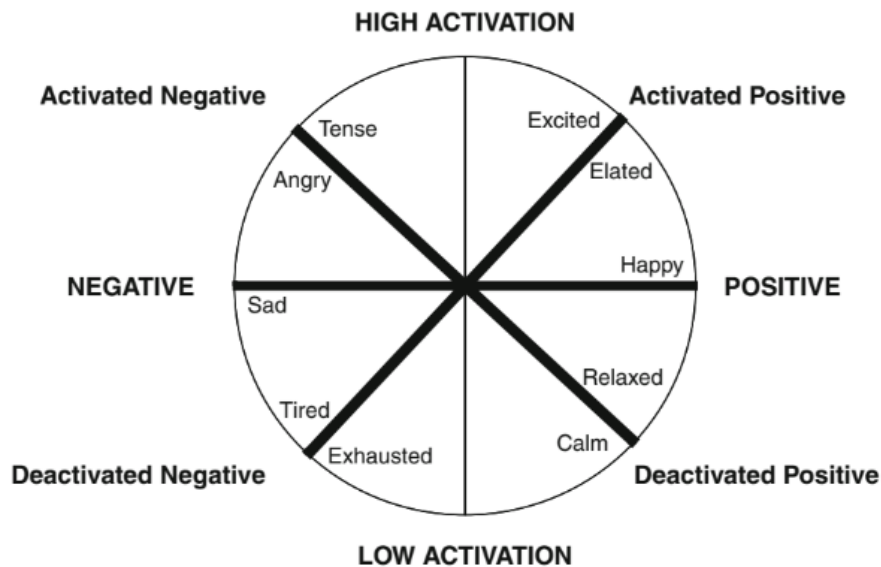


Figure 1: Affective Circumplex Model [17]

Methods

This participant pool for this study derives from a larger study addressing the experiences of Black engineering graduate students. The larger study used narrative interview methods to capture stories of the lived experiences of Black graduate students in engineering. Participants participated in narrative interviews that were initiated with a prompt that composed the narration phase. The prompt stimulated participants to share their experiences in navigating engineering through undergraduate and graduate school, including how they perceived facets of their identity and engagement with specific organizations to impact their experience. This encouraged participants to elaborate on their stories. Following this was a conversational phase, a semi-structured approach was taken to follow-up on specific points based on the stories shared by participants. The conversational phase consisted of questions meant to delve deeper into the experiences shared.

In order to participate in the study, three inclusion criteria had to be met. The participant must: (1) identify as Black; (2) be enrolled in an accredited doctoral engineering program; and (3) have engaged in either NSBE and/or BGLOs as an undergraduate student. As an initial recruitment effort, a demographic survey was deployed to targeted institutions through networks of Minority Engineering Program advocates and listservs associated with Black engineering organizations. More than 60 Black engineering graduate students completed the demographic survey as a result of the snowball sampling that occurred as students shared the study with their own professional networks and peers. A total of 37 interviews were collected from Black graduate students across the nation. Interviews were 1.5 – 2 hours in duration; audio and video recorded; and transcribed via Rev. Participants were compensated for their time via a \$100 amazon gift card. The research team adopted a narrative interview approach to address the phenomenological question guiding the work, exploring how Black graduate students emotionally experience navigating engineering. For the purpose of anonymity, participants were given the option to choose a pseudonym to attach to their stories. The stories of a subset of 5 participants, out of 37 total interviewed, were chosen to be analyzed for this study. The descriptors of the participants are included in Table 1.

Table 1: Participant Demographic Information

Pseudonym	Gender	Year	Engineering Major		Institution Type	
			Undergraduate	Graduate	Undergraduate	Graduate
Dani	F	3rd	Mechanical	Mechanical	PWI	PWI
Melody	F	4th	Nuclear	Bioengineering	HBCU	PWI
X	M	2nd	Mathematics	Industrial	HBCU	PWI
Joshua	M	1st	Chemical	Chemical	PWI	PWI
Olivia	F	3rd	Mathematics	Industrial	PWI	PWI

The 5 participants chosen for this study were a subset of a larger, national study of Black engineering doctoral students in accredited engineering programs across the country. These 5 participants were chosen due to the emotional content that was conveyed during their interviews, whether it was through their experiences and how they responded, or the emotions that arose during their recounting of their stories.

Emotion coding was used for the first-cycle coding method to draw out the explicit and implicit emotions expressed during their recount of their experiences in engineering. Emotion coding [18] inductively applies emotions to excerpts as the participants describe their experience. Aspects such as tone, verbiage, and expressions were used to identify emotions that were not directly verbally communicated. To accurately differentiate positive and negative emotions, emotion explanations from Desmet [19] was utilized. These sources provided the vocabulary for emotions inferred by the researchers based on the context of the participant’s story, the vocabulary they used, and what the participant was actually describing. For example, the participant might use the word “weird” to describe an experience that discomfoting or discouraging. Therefore, the code application would be “uncomfortable”. Between the first and second cycle of coding, the technique of code mapping was utilized to categorize the raw emotions from the stories into fitting buckets as a means of organizing similar data [18]. The

research team reviewed and coded the transcripts and then discussed the code applications collectively to confer on agreement regarding the interpretation of the emotions and the code application. Finally, we used a combination of pattern coding and the application of the Affect Circumplex model to properly classify the emotion categories with respect to activation energy (high or low), and valence (positive or negative). The individual pattern coding applications were then discussed collectively to provide different perspectives and insight to the themes presented. Once the emotions were classified, the stimuli surrounding the emotions were analyzed and themes were presented regarding the emotional navigation of engineering for Black graduate students.

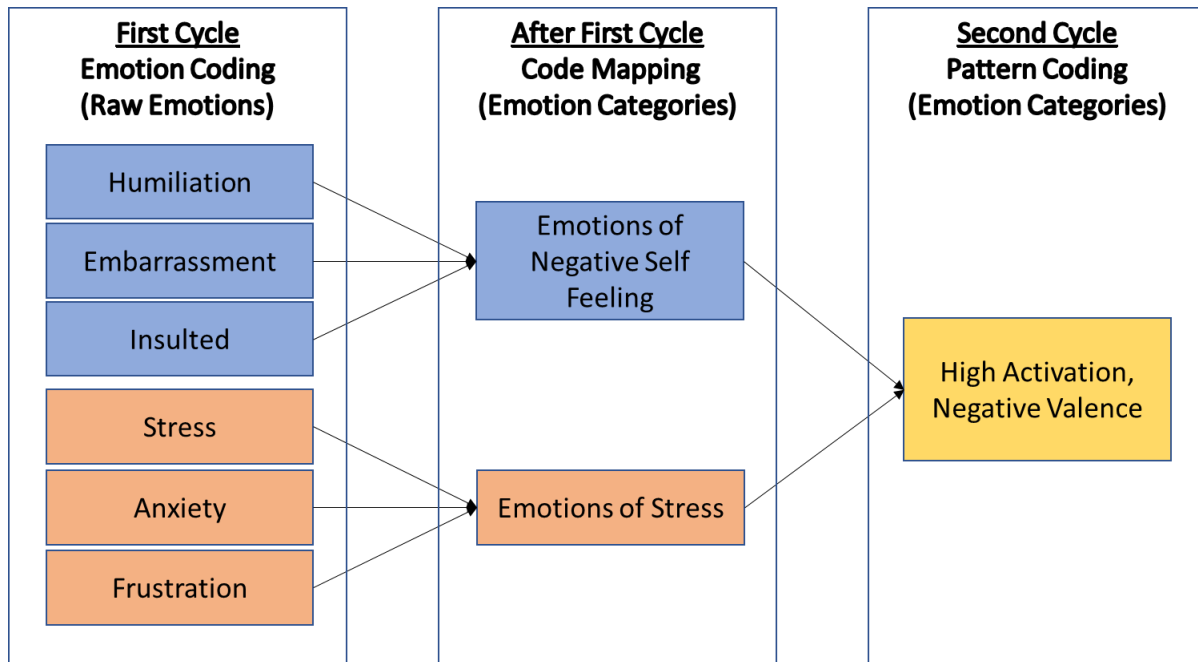


Figure 2: Example of data analysis method for consolidating emotion codes

The research team consists of the PI and two graduate researchers all within the engineering education program. All the team members identify as Black, with two researchers identifying as female and one researcher identifying as male. All the researchers have engineering backgrounds and have experience in industry, academia, research, and government.

The findings of this qualitative study are not intended to be generalizable for all Black engineering students given the small sample size, though it adds to the depth of the data. The aim of this sought to identify emotions of Black engineering graduate students and uncover the consequences or implications of them as described through the stories of Black engineers allowing the research team to delve into the richness of the participants stories. Additionally, the emotions described by this study are not the only emotions experiences by Black graduate students. In spite of the limitations, this study adds to our understanding of how Black engineering students navigate, perceive, and respond to engineering spaces.

Findings

Engineering is experienced in unique ways depending on the settings and the student involved, which ultimately led to different perspectives and different expressions of emotions across the participants. Across all the participant stories, there were a plethora of emotions that were expressed both explicitly and implicitly. A total of 44 unique emotions were identified across the experiences of the participants, which were then separated into four categories via the Circumplex Model: high-activation with positive valence (8), low-activation with positive valence (8), high-activation with negative valence (17), and low-activation with negative valence (11). The explicit emotions expressed in the transcripts can be found in Table 2. Negative valence emotions are more prevalent within the stories of the Black engineering graduate students, accounting for 28 of the 44 (63.6%) emotions identified across the participant stories. When the activation of the emotions is considered along with the negative connotation, the number of high-activation negative emotions greatly outweighs the number of low activation negative emotions. Positive valence emotions were less salient across the stories of the participants. Even during times of great success there were participants who found it difficult to view the situation in a manner that allows them to express an active pleasant emotion. The activation energy of the emotions was more evenly distributed across the 4 classifications with the same number of positive valence emotions considered high and low activation.

Table 2: Emotions Expressed by Participants Classified via Affective Circumplex Model [3].

	Low Activation	High Activation
Positive Valence	Confidence, Pride, Hope, Relief, Satisfaction, Gratitude, Admiration, Motivated	Excitement, Anticipation, Joy, Surprise, Fascination, Courageous, Adventurous, Determined
Negative Valence	Doubt, Sadness, Disappointment, Distress, Guilt, Annoyance, Confusion, Dissatisfaction, Sympathy, Uncomfortable, Isolation	Anxiety, Insecurity, Pressured to Succeed, Shock, Anger, Rejection, Embarrassment, Humiliation, Anticipation, Frustration, Envy, Pity, Resentment, Lack of Belonging, Disbelief, Disheartened/Discouraged, Intimidation/Fear

High-Activation Negative Valence Emotions

High activation emotions are often much more involved than low activation emotions because of the amount of energy that it takes to express them. *Stress, embarrassment, and anger* are a few common high-activation negative valence emotions, that were found across the participant stories. Due to some of the barriers that Black graduate students often face, high-activation negative valence emotions are the most common type of emotion expressed. This is often in response to a situation in which they feel judged or underappreciated because of their identities. Melody, a 4th year bioengineering student, became increasingly frustrated when dealing with the peers in her lab and how they treat her when it comes to her work in the lab:

A lot of us put each other on the same level, but something that the graduate students will do is, if I'm saying something, they need to verify it. Where I may say, "I got 59 for this image, and 72 for this one," it's like they have to look at the screen and say, "oh, you got 59 for this, and 72 for this." And I'm like, I just said that. And this really ... it's definitely irritating, having to prove yourself over again.

Emotions such as exasperation, frustration and resentment come across very clearly in this quote. Being in her fourth year, Melody has constantly had to deal with this relentless internal and external pressure to prove herself to those in her lab, which has affected the way that she was able to interact with her peers, as well as her willingness to engage in certain activities. The frustration that Melody feels due to this situation is not a foreign emotion for many of the participants in this study. All five participants for this study indicate some sort of frustration with the fact that, because they are Black within the graduate space, they feel the need to constantly prove themselves, much like Melody. This prolonged exposure to these very activated emotions has the potential to leave these students tired, unmotivated, and disengaged with their work, should it be the source of their discomfort within their respective engineering environments.

High Activation Positive Valence Emotions

Though they take a lot of energy, high activation emotions can also be very positive and contribute positively towards the goals of the students experiencing them. These emotions will fall into categories such as excitement, joy, fascination, and determination. Dani, a 3rd year mechanical engineering student, while explaining her journey through engineering, expresses her elation at being accepted into graduate school and working with a professor whom she adores.

...so I'm here and I'm really happy I'm here. I think this is like definitely the best decision for me, because she's an awesome advisor. And I'm really excited to be in graduate school.

The salient emotions that come through explicitly in this passage is that of excitement and happiness. Dani, being in her third year, has been able to maintain the joy that she felt when she was first admitted to graduate school, which helps her to keep a positive attitude as she moves forward and completes her program.

Low-Activation Negative Valence Emotions

Low activation emotions are those which carry a low cognitive load when these emotions are shown, or do not necessitate a large amount of energy to experience. Examples of these emotions are *doubt, disappointment, dissatisfaction, and annoyance*. Joshua, a first-year chemical engineering graduate student, realized many low activation emotions when reflecting on his own experiences undergraduate organizations. Early on in his college career, Joshua recalls feeling an aversion to a minority serving organization because he felt it “wasn’t meant for someone with [his] background” being in good academic standing. Reflecting on this experience Joshua explains his thought process throughout the situation.

I felt like, as black student myself, I came from an inner-city context where there weren't a lot of resources that we had. In a way that I wanted to do better and support my community, but I also wanted to get out of it. I didn't want to be [Joshua] from the hood. I didn't want to be seen like that, even though that was a community that I wanted to serve.

Because this statement was spoken in a somber tone, this statement conveys feeling of disappointment, sympathy, and guilt. Joshua did not want to associate with his inner city identity because of the negative connotation it holds, specifically in the academic space. Though he bares this sadness constantly, the deactivated nature of these emotions allows for them to be sustained long term with less cognitive fatigue.

Low Activation Positive Valence examples

Olivia, a 3rd year industrial engineering graduate student, faced many challenges that she had never experienced before when she matriculated into graduate school, many of them having to do with her ability to balance her responsibilities as a researcher and her place in her lab, where she felt she had to work harder to show that she belonged. She described how she felt very little support from those close to her because of their inability to understand what she was going through. Despite this, Olivia was able to find the support she needed through her faith, allowing her to gain the confidence and self-image that was necessary for her to succeed in her field

Instead of focusing that energy towards proving myself, it is just focused now towards being the best researcher or engineer that I can be. And if people, if that makes them think highly of me great but if not, I am still okay because it is not my goal to make them think a certain way.

Till this point, Olivia had been struggling with the pressure to prove that she belonged in her program. With this shift in mentality, we see her confidence grow to the point where she is content with her goals. Here we see emotions of confidence, pride, and satisfaction as she moves through her program and learns to navigate as a Black woman within the engineering spaces. It is worth noting that confidence and pride in this space did not come naturally to Olivia, as she relied on her many support groups to develop the mentality necessary to achieve this state. Navigating engineering is an extremely difficult task on its own and is often made much more

difficult when an individual feel unwelcome or a lack of belonging within engineering spaces. Since Olivia is no longer putting energy towards having to prove herself, she not only saves energy in her everyday interactions, but is also able to convert some of her negative emotions, such as stress, and pressure to succeed, into positive emotions such as confidence and satisfaction.

Discussion

Currently there is much research relating the influence of emotions to different aspects of their academic experience, indicating that emotions and their effects can have significant impact on student's academic learning, achievement, personality development and overall health [20] [8] [21] [22]. Of the expressed emotions in this study, high-activation emotions with negative valence were most salient among participants, which have been associated with both a lack of motivation and efforts to avoid failure [7]. Enduring high-activation, negative emotions over time can have implications for anxiety, depression and other mental health concerns, due to their high energy cost. In addition to the classification of emotions through valence and activation, how emotions can be categorized by object focus, to help understand the areas where emotions manifest [7]. While researchers have explored the effect of emotions for the general engineering population, Black engineering doctoral students will navigate spaces in a different manner than their majoritarian counterparts. The disaggregation of these stories helps to elucidate the lived emotions of these students, and how they differ based on perceived experiences while engaging in both undergraduate and graduate engineering spaces.

Emotions can intersect within all the ranges of valence and activation. Achievement emotions are related to activities that have some element of judging one's competency. From the participant stories, achievement emotions were described when they discussed their experience with their qualifier examinations. They reported a variety of emotions such as anxiety towards how they will be viewed being Black in engineering, anger at having to prove oneself, and relief in success despite barriers they faced. Pekrun also describes topic emotions as emotions evoked when learning or covering a topic in class. These emotions can impact a student's interest and engagement with the material of the field. Lastly, Pekrun describes social emotions as related to interactions with other persons. This can be critically important within student-teacher or student-student interactions [7].

While Pekrun provides a general base for object focused emotions; the emotions experienced from the students in the study are not captured fully within these descriptions. For example, Joshua describes:

It makes me think about how those dynamics would be different. How I wouldn't have to feel like I'm walking on eggshells. Or even now, how I wouldn't have to feel like I would have to, "Oh, is she giving me this look because my stuff is wrong or because she doubts me? And why does she doubt me?" There are a lot of thoughts

I have I don't think I would have if it was a Black advisor. But that's a whole new can of worms.

The element of identity was a factor that Joshua was considering when reflection upon his interactions with his advisor. The advisor-advisee relationship is a very complex power dynamic with the capability of greatly impacting a graduate experience for Black males [23] [24], potentially eliciting both positive and negative emotions [25]. The constant fear of inadequacy or failure drives Joshua to act cautiously around his advisor, because of the dissonant racial identities present. Given the long term nature of advisor-advisee relationships in engineering, the prolonged exposure to this high-activation negative valence emotions could give rise to mental health issues such as anxiety and depression, as well as loss of motivation [7]. Many of the students expressed emotions that stemmed from their identity such as responsibility, obligation, shock, and anger. The frequency of which students experience the range of identity-affiliated emotions is a critical component to understanding the climate which these students are navigating. McGee argues that this racial lens is necessary to explore the mental health and emotional responses of Black students due to the frequency of which they encounter discrimination and bias [13]. Thus, these types of emotions must be viewed and interpreted taking into account concepts such as weathering and racial battle fatigue, as students cope with stereotype threat [26] and John Henryism, where they feel the need to work themselves to the point of exhaustion to prove their worth. This is especially prevalent in Black engineering doctoral students as asserted by Robinson et al. in a study on racial and gendered experiences stating that Black doctoral student “felt they had to expend extra energy to prove themselves to their advisors, professors, peers and even mentors” [27] forcing them to go the extra mile just to be seen on the same level as other, majoritarian students

Additionally, identity is prevalent in how these students’ emotions indicate application of coping mechanisms. Boekaerts discussed emotion-focused coping strategies and problem-focused coping strategies [28]. Emotion-focused coping strategies applies strategies that attempt to regulate negative emotional responses such a denial or avoidance. Problem-focused attempts to use purposeful efforts to manage a stressful situation. For example, Olivia’s describes:

This is what they think engineering looks like: white men for the most part. And I am not that, at all. I feel like I had to prove myself, even when no one was telling me, "Olivia, you don't belong here.". In my mind it is like I have to show you that this is where I belong.

Olivia’s emotional response to this identity related experience was to prove herself. While this is an example of a problem-focused coping mechanism she could have decided to cope in a variety of ways.

Olivia and Joshua both expressed indicators of imposter syndrome through only their emotions and responses to identity related situations. This was prevalent and many of the stories portrayed by participants, as we saw almost exclusively negative-high valence emotions as responses to racialized experiences. Even students such as Olivia, whose emotional response was that of determination, run the risk of burnout and overworking herself, ultimately resulting in a lower likelihood of retention. Emotions are very powerful in directing actions and mindsets, especially

in the academic context. This reinforces the need to understand and respond appropriately to the unique emotional experiences of Black engineering graduate students if diversity, inclusion, and retention are truly paramount to the advancement of engineering as a field.

Conclusion, Implications, and Future work

This study warrants continued investigation into emotions and their link to mental health for Black engineering graduate students. We believe mental health to be critical and rooted in effective efforts to broaden participation in engineering, which will seek to better understand these students' experiences as a reflection of the culture, changes to be made for improvement, and identification of opportunities for macrolevel structures to be accountable for all students' success. This could include revisiting institutional policies, incorporating sensitivity training goals for faculty, and looking at the interactions between students and faculty. This study informs the range of emotions that Black graduate students in engineering are experiencing, where they manifest from, and how these students cope with it. Considering the amount of experiences that these students face that fall into the high activation, high negative area suggests that these students spend a lot of time in this headspace. How does this impact their engineering agency or their motivation to persist? Future work will discuss the greater implications of how these emotions impact these student's mental health, coping strategies, and responses that can alter their engineering trajectory, as well as investigating critical incidents that elicit significant emotions and their effect on Black graduate student mental health and persistence. By understanding this, we can shift the amount of negative emotions towards positive ones that promote Black students to pursue and persist in advancing their education in engineering.

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