Environments Affecting Black Student Thriving in Engineering (BSTiE)

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Abstract
Studies of Black students' experiences and journeys to success in engineering programs at Predominantly White Institutions (PWIs) show that Black students face significant hardship. We must view their experiences through a lens considering multiple factors. It is no longer feasible for students to "wait on the world to change" in engineering programs that perpetuate negative experiences. Stakeholders of these programs must take stock of the state of their culture and assess if the environment they have cultivated is conducive to the diversity goals they set out at the onset of every academic year.

In a previous conceptual paper, we proposed a new framework, Black Student Thriving in Engineering (BSTiE, pronounced "bestie"), to describe what factors contribute to the thriving process based on several existing theories. Six components emerged: (1) internal environment, (2) competence, (3) motivation, (4) belongingness, (5) assimilation, and (6) external environment. The internal environment provides individual context – one's cultural commitment and identity. Competence is how students perceive engineering concepts and their ability to achieve them. Motivation is a student's willingness to succeed in engineering. Belonging is a student's perception that they belong in their engineering program at a PWI. Assimilation encompasses how students grapple with who they are and who they think they need to be in engineering. The external environment provides a discipline-based context – the engineering culture at one's PWI.

We aim to expand on these emerging themes by focusing on how the internal and external environments affect the thriving process. The previous conceptual paper identified gaps in our understanding of the internal and external environments that must be explored. Specifically, while internal and external environments interact through students' sense of competence, motivation, belonging, and assimilation, there is a need to understand how the external environment affects those student attributes that are key to their thriving. We will leverage theories that speak to the gender-based racialized experiences of Black students and the racialized nature of institutions. We aim to provide insight into the institution's role in facilitating thriving for Black engineering students at PWIs.

Introduction

The experience of Black students in engineering programs at predominantly White institutions (PWIs) is rife with inequities in participation and racial stereotypes about ability and competence [1-4]. While Black students navigate their way to success in engineering programs not created with them in mind, they often survive rather than thrive [5-6]. A literature review examining engineering student success found that success is often defined as a collection of academic competencies that traditionally excludes the overall well-being of engineering students in the context of their academic environment [7]. Success for Black students in engineering programs at PWIs beyond their academic achievement includes how they maneuver their identities within the cultural landscape of the engineering programs at their university [8].

Positive psychologists define thriving as a process that allows individuals to rise to a function that exceeds their circumstances. Existing literature identifies predictors of thriving among students of color [9] and a model of thriving for all students in engineering [7]. However, none of these studies explain how Black students thrive in engineering.

Adopting thriving from positive psychology, we define being a Black engineering student at a PWI as the circumstance and flourishing within the engineering culture of the engineering program at the PWI as the level of functioning that exceeds that circumstance. Thus, Black student thriving in engineering is the process of being a Black student at a PWI and flourishing in the engineering culture of the engineering program at their PWI. In a recent publication, we proposed Black student thriving in engineering (BSTiE) as a conceptual framework to explain the factors that affect the thriving process for Black students in engineering programs at PWIs: competence, motivation, sense of belonging, assimilation, and the internal and external environments [8]. BSTiE positions Black student thriving as a holistic view of success, highlight the relevant constructs that impact Black student thriving in engineering at PWIs, and outlines the role that PWIs play in how Black students can thrive in their engineering programs. The previous paper was limited in its description of how the internal and external environment affects the thriving process of Black students in engineering at a PWI [8]. We aim to provide a brief review of the establishment of BSTiE as a conceptual framework followed by an in-depth description of the internal (cultural commitment and identity) and external (engineering culture at PWI) environment.

Black Student Thriving in Engineering

Black Student Thriving in Engineering (BSTiE, pronounced “bestie”) is a culturally relevant conceptual framework situated at the cross-section of Engineering Thriving, Engineering Identity, and Black Student STEM Identity to provide a holistic structure of the Black experience in engineering at PWIs. Each theory lacks representation of the thriving process for Black students in engineering. Aggregated, they create a description of the factors at play when Black students attempt to thrive in engineering programs at PWIs. We pulled commonalities between each theory to describe the thriving process. We define thriving as flourishing as a Black student in the culture of their engineering program at a PWI. We found that for Black students, the thriving process was impacted by: (1) their cultural commitment and identity, (2) how they perceive engineering concepts and their ability to achieve them, (3) their willingness to succeed in engineering, (4) their perception that they belong in their engineering program, (5) the extent to which they undergo tradeoffs with who they are and whom they think they need to be in engineering, and finally, (6) the engineering culture at their PWI [8]. We defined these factors as the internal environment,

competence, motivation, sense of belonging, assimilation, and external environment, respectively. We created Figure 1 to visualize the constructs.

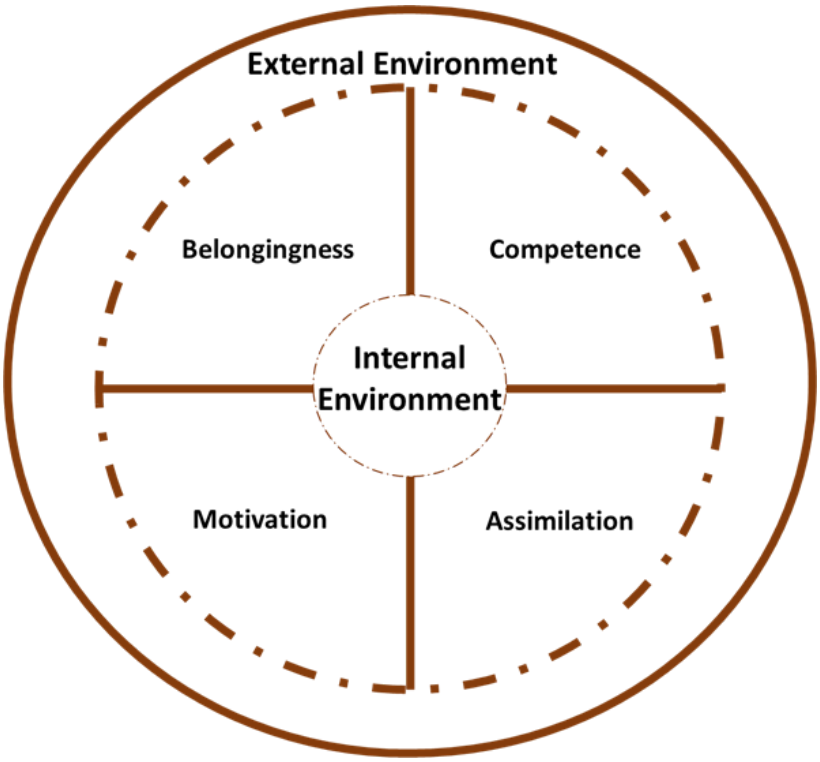

Figure 1: The conceptual framework of BSTiE for the proposed study [8]

We will leverage the guiding theories, Black student STEM identity [10], engineering identity [11-12], and engineering thriving [7], to establish the existence of the environments. We will also leverage other theories that lend to our understanding of how the internal and external environments affect the thriving process for Black students in engineering. While the internal environment is heavily studied, I aim to contribute to the existing literature gap outlining the external environment's role in the experiences of Black students in engineering and their thriving process within engineering programs.

Theoretical Frameworks that Inform BSTiE

This section will discuss the theories that inform BSTiE, specifically in the internal and external environment established in Figure 1. I will provide an in-depth description of how each theory refers to the internal and external environments to provide a foundation for understanding how we placed the internal and external environments in the graphic and how they affect the process of thriving for Black students in engineering at PWIs.

Black Student STEM Identity

Collins [10] leverages two student success models to extract constructs of BSSI, Black Male Scholar Identity [13] and Ford Female Achievement Model for Excellence [14]. While these two theories inform all of the constructs, I will focus on Collins' [10] rationale to define gender-based racial identity, internal environment, and external environment as influential to a Black student's STEM identity, as visualized in Figure 2.

A student's gender-based racial identity is the innermost construct of Black student STEM identity. This construct acknowledges the unique experiences and identity development of male and female students who identify as Black. How they have achieved different stages of their racial identity development affects their STEM reflective identity, competence/ability, value/interest, and assimilation into STEM culture [10]. Black males and females construct their STEM identities as they develop their gender identities. Collins [10] notes how racial identity development and gender identity begin to form before the development of any STEM interest. The relationship between Black students' gender-based racial identity and their interest and persistence in STEM is complex. Collins [10] places the gender-based racial identity of a student in the center of the visualization to mirror how central it is to the other constructs. Black students value their gender and racial identity differently throughout developmental stages.

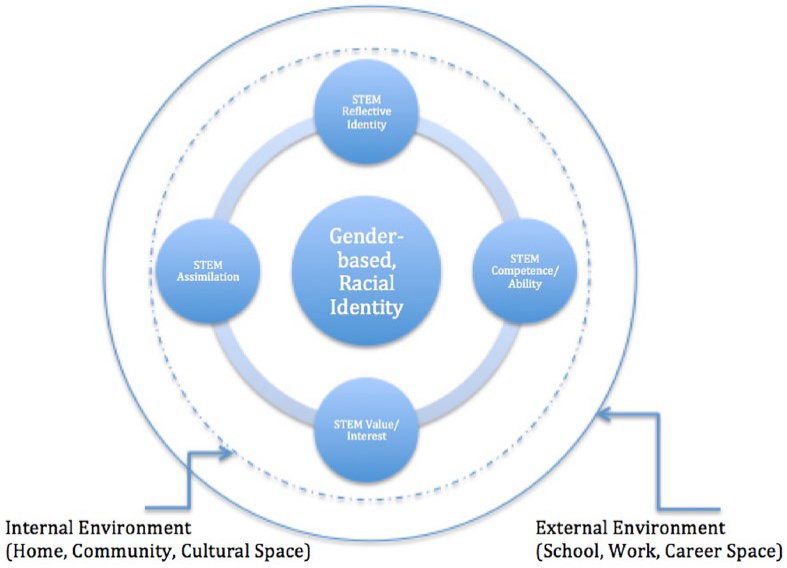

Figure 2: Contextual model for Black student STEM identity from Collins [10].

Collins [10] presents a separate construct called the internal environment which delineates how Black students begin to understand themselves in their own culture. Within this environment, their reflective identity, competence/ability, value/interest, and assimilation in their STEM environment are influenced by their understanding of themselves. The internal environment includes a student's home life, community, and cultural spaces. This environment reinforces a Black student's gender-based racial identity. Collins [10] defines the external environment as the institution of schooling, the workspace, and the career space in which a Black student in STEM is situated. This environment influences a Black student's STEM identity because it houses the academic interactions Collins [10] defines as the microcosms that develop a STEM identity. The external environment should also reinforce a Black student's gender-based racial identity. However, Collins [10] identifies how external environments traditionally threaten a Black student's gender-based racial identity by perpetuating a chilly STEM climate through stereotypes and gender biases. Nevertheless, she points out the need for Black students to cultivate STEM identities in external environments that are welcoming of their gender-based racial identities. The extent to which a Black student's internal environment aligns with their external environment has lasting effects on their STEM identity development and, consequently, their persistence and success in STEM.

As Collins [10] defined, the internal environment serves as a direct reinforcement space for their gender-based racial identity and exists separate from a Black student's external environment. Still, their alignment remains imperative to a Black student's identity development. Students grapple with commonalities and differences between the core values of the two environments. At the model's center, gender-based racial identity centralizes the intersecting ideologies of gender and race expectations that Black students navigate innately. Thus viewing a Black student's identity development in the context of engineering is necessary to understand their thriving process. We leverage engineering identity, as defined by Godwin [12], to begin the shift to this perspective.

Engineering Identity

Engineering identity is a role identity developed to conceptualize how students identify with being an engineer. In her development of engineering identity as a theoretical lens of analysis, Godwin [12] built upon the work of Hazari et al.'s [15] description of science identity. Godwin [12] presented two key analyses where measures were tested and created to understand the constructs of engineering identity as performance/competence, interest, and recognition, as visualized in Figure 3. Damas & Benson [8] outlined the significant contributions of engineering identity to the thriving process of engineering students and the unique manifestation of engineering identity for Black students. While engineering identity contributed to the creation of BSTiE, a study conducted by Fleming et al. [11] lent to our understanding of the role of demographic characteristics (i.e., gender and race) in the development of engineering identity from their study of Black and Hispanic students at minority-serving institutions (MSIs). This study found that Black students' engineering identity must be seen through the lens of who they are culturally because the influences were endemic. I leverage this study to discuss how engineering identity contributes to the internal and external environments of BSTiE.

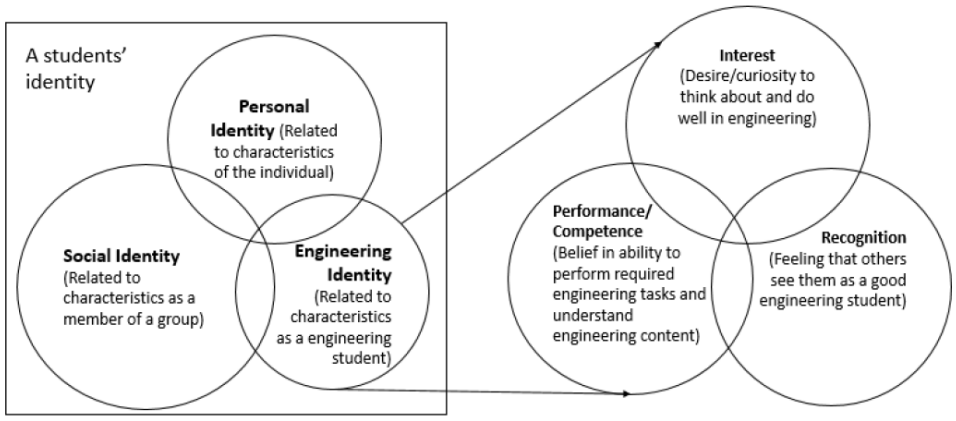

Figure 3: Framework for students' engineering identity adapted from Hazari et al. [15] and expanded by Godwin [12]

Fleming et al. [11] found that Black students felt a strong sense of community cultural commitment as they took on engineering. Students felt like their degrees were greater than them and thus felt motivated to enter and persist in engineering. Students noted how a shared identity with peers positively influenced their identity development. Even further, students viewed their roles as engineers in tandem with their racial identity. When asked to identify characteristics of engineers, they included possessive markers like "we" and "our." While some may lean towards color-blind ideology to view their statements as an eliminator of race, Fleming et al. present these findings as a strong sense of combined

self. The Black students were not unaware of stereotypes and microaggressions. Instead, they were empowered as Black engineers at their MSI. There was no separation of their Black selves from their engineering selves. Their racial identity development also influenced the extent to which they felt they belonged in engineering, thus bolstering their identities as engineers at their MSIs. This study is limited in generalizability due to its focus on Black and Hispanic students at MSIs. Nevertheless, the findings are an additional pivoting point to understanding Black students in engineering: external environment matters.

Fleming focused on the stories of Black and Hispanic students in engineering programs at MSIs. Looking specifically at the stories of Black students, they found that the engineering culture at their institutions was influential. Black students identified their engineering culture at their institution as rigorous rather than an exclusive rigor that presented as a weeding-out mechanism. They identified the rigor of their courses and curriculum as making them “good” engineers. Many participants leaned into the rigor and believed in it. Their engineering culture was inclusive and purposeful. Students highlighted the culture of engineering professors and staff as caring and intentional. They knew they belonged and were wanted in their engineering programs as a result of this. They felt the structures in place supported their goals and achievement in engineering. This influenced the students' success through their engineering programs by reinforcing and positively developing their engineering identity.

Engineering Thriving

Ge & Berger [7] identified academic, intrapersonal, and interpersonal competencies that have been identified as contributors to success for engineering students. Academic competencies include students’ understanding and achievement in engineering courses measured by GPA, graduation, retention, and assessment. Intrapersonal and interpersonal competencies are intrinsic personal characteristics that form through a student’s development. Engineering thriving is the optimization and expansion of academic, intrapersonal, and interpersonal competencies for engineering success. These competencies are cultivated and strongly affected by the engineering culture, which lends to the thriving process. Thriving can only be understood and defined in context, so the authors provide an in-depth description of the context of engineering culture. This lends directly to our understanding of the external environment of BSTiE.

Engineering Culture

Ge & Berger [7] establish the context of thriving within the engineering culture to identify the uniqueness of students' experiences in engineering. Many thriving models have been created over the years and are specific to a context because thriving is context-dependent. The positioning of the engineering culture in the visualization of engineering thriving was strategic. Ge & Berger [7] defined thriving as a process supported within an environment. Thus, the engineering culture plays an essential role in the extent to which students thrive in engineering. They leveraged existing reports from the National Academy of Sciences, Engineering, and Medicine to define engineering culture as a set of explicit and implicit expected behaviors, norms, and normative attitudes within engineering education. It is important to note how engineering culture, while uniform in its basic definition, manifests differently at different institutions and programs.

Nevertheless, engineering culture is traditionally negative and characterized by strife and struggle. The roots of engineering culture stem from engineering’s military origins in America. This origin created a

belief that engineering was a boot camp where hardship, selectivity, and difficulty are viewed as points of pride [7]. This toxic culture shapes most engineering programs. This culture significantly affects engineering thriving because of its direct impact on the competencies identified in Figure 4.

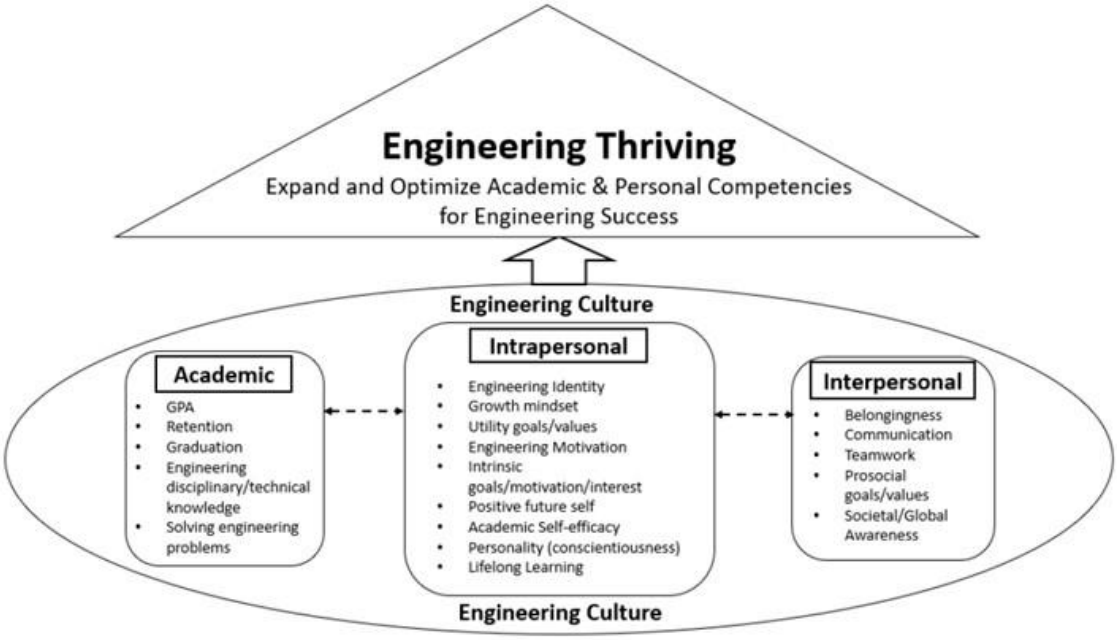

Figure 4: Conceptualization of Engineering Thriving. This framework represents individual competencies of thriving relevant to undergraduate engineering students [7]

Ge & Berger [7] leverage existing studies to explain how the culture of engineering traditionally negatively affects the thriving process for women and minorities—the culture bolsters beliefs of who belongs in engineering and who can do engineering. Indeed, engineering culture can exist differently for different demographic groups. Ge & Berger's [7] analysis is limited in its understanding of the unique experiences of different demographic groups and the institutionalized effect of engineering culture on their thriving process. Engineering thriving, as is, provides a foundation for considering the engineering culture within a program and the extent to which it can support or inhibit the thriving process. However, its limited consideration of differential experiences presents a gap in our understanding of how Black students' racial identity affects how they thrive in engineering

Conceptualizing the environments of BSTiE

This section will aggregate the guiding theories to develop a grounding definition of the environments at play in thriving for Black students in engineering. While the three theories that ground BSTiE establish the existence and importance of the internal and external environment, they do not adequately describe how the internal and external environments manifest in the thriving process for Black students in engineering. I lean on the works of other scholars to further conceptualize the internal and external environments.

Internal Environment

The internal environment is defined as a cultural context–one's cultural commitment and identity–in which Black students are innately/inherently situated. The thriving process for Black students in engineering begins in the internal environment, as this environment shapes how they view their engineering experiences and interactions. Through Black student STEM identity, we found that racial identity development progresses with STEM identity and affects how students view themselves within their discipline context [10]. Engineering identity, as enacted and portrayed in the experiences of Black students at an HBCU, further prove that Black students develop their engineering identity with their racial identity [11]. Fleming et al. [11] highlighted how Black students' sense of combined self helped them to feel good and function well in their engineering programs. In their conceptualization of engineering thriving, Ge & Berger [7] did not contribute to understanding how one's cultural commitment and identity may affect the thriving process. While the grounding theories (i.e., Black student STEM identity [10], engineering identity [11]) establish that the cultural identity found in the internal environment of BSTiE affects thriving, they are limited in describing how this identity is enacted throughout a Black student's academic journey. We leverage supplementary theories to make sense of the relationship between the internal environment and how Black students experience engineering education.

Black students develop their racial identity over time. Cross [16] identifies three major stages of racial identity development: pre-encounter, immersion/emersion, and internalization. The stages manifest in different ways at different times in the life of a Black person. For Black students in education, this development can take many forms. In an adaptation of Bronfenbrenner's ecological systems theory, Stern, Barbarin, & Cassidy [17] identified multiple markers specific to Black students in America as they understand who they are. Events, people, experiences, and more in the chrono-, macro-, exo-, meso-, and micro-systems of a Black student's life affect their overall development, including racial identity [17]. They identified that education systems exist in the exo- system of a student's life and significantly affect how they make meaning of being Black. Many Black students receive their initial understanding of Blackness from home; however, this understanding can be reinforced or challenged outside the home. For Black students in engineering, the thriving process is positively affected when their understanding of Blackness is reinforced in their experiences and interactions in engineering. Blackness can take shape differently, as all Black students do not exist within a specified racial boundary.

Rejecting the monolith

Being Black is a shared identity among Black students, but they are not a monolith. Collins [10] emphasizes the role gender plays in developing a STEM identity by including a gender-based racial identity. Her gender discussion was limited to a binary view of gender: women and men. Building on this viewpoint, we leverage intersectionality theory [18] to understand the multiple intersecting identities that further characterize the identity development of Black students. In higher education, this theory has been widely used to depict the intersecting layers of racism, stereotypes, and biases that negatively affect the success of women of color [3] and, more recently, the lived experiences of people with multiple minoritized identities (i.e., queer identities, ability identities, and socioeconomic identity). Black students that exist at the intersection of multiple identities even face racism as students in the communities of their non-racial identities. Intersectionality studies show us how race is salient across identity groups. Studies that outline women's experiences found that White women receive higher

regard than Black women [19-20]. In the queer community, Black queer students must navigate experiences that their non-Black counterparts do not have to [21-22]. Black students with disabilities, physical or learning, have also witnessed how inequities in education lead to policed access to resources [23]. There are multiple intersecting identities that Black students inherently have, including but not limited to the previously mentioned identities. In all cases, it is essential to acknowledge that being Black affects students' overall development and understanding of who they are. Their understanding of who they are drives their initial perceptions of their ability to understand engineering concepts (competence), their sense of where they do or do not belong (sense of belonging), their will to succeed (motivation), and the extent to which they assess tradeoffs between who they are and whom they need to be in engineering (assimilation).

Placement

Collins' [10] construct of the internal environment and gender-based racial identity can be merged to demonstrate how safe cultural spaces outside the discipline context serve as a Black student's prior understanding of who they are. Their home, church, and community, which Collins [10] identified as the internal environment, shape how they view themselves as people. The placement of the internal environment at the center of BSTiE represents how Black students navigate their sense of belonging, assimilation, competence, and motivation in engineering programs at PWIs through their cultural commitment and identity. The internal environment does not control or affect the environment at a PWI. Thus the internal environment is not visualized near the external environment.

External Environment

The external environment of BSTiE is a discipline-based context characterized by the engineering culture at one's PWI. Black student STEM identity [10], engineering identity [11-12], and engineering thriving [7] provide insight into how the external environment enacts in the experiences of Black students. Through the lens of Black student STEM identity [10] and engineering identity [11-12], we found that Black students need to have their perceptions of whom they are reinforced in their discipline context. Specifically, the culture of engineering at their university must affirm their Blackness to create an environment conducive to thriving. Engineering thriving also positions the engineering culture as an important context for the thriving process, specifically mentioning how engineering culture can facilitate differential experiences for demographic groups [7]. The common thread among the grounding theories is that the extent to which a Black student can function well and feel good depends on how the engineering culture perceives Blackness.

Engineering culture manifests itself in many ways. In Black student STEM identity, engineering culture is characterized by interactions between Black students and other actors in their discipline [10]. Engineering identity characterizes engineering culture as the handbook of what an engineer is and does [11-12]. Engineering thriving characterizes it as a collection of beliefs that drive what is acceptable and unacceptable in engineering [7]. While each grounding theory acknowledges engineering culture as influential to the extent a Black student can thrive in engineering, they contribute a limited understanding of how Black stduents experience engineering culture. We leverage the work of supplemental scholars to provide an in-depth description of the nature of engineering culture at PWIs.

Historical Context

We must first consider the institutionalized racist nature of education in America to situate engineering culture. BlackCrit, as theorized by Dumas & Ross [25], defines anti-Blackness as Black people living in the afterlife of slavery [26] in which Black humanity and human possibility are threatened and disdained by racial and political historical establishments [25]. Anti-Blackness was among many racial schemas upheld by founding stakeholders in American education. Higher education has historically engaged in the unequal covert treatment of Black students. Scientific racism in the 19th and 20th centuries was a product of perceptions and beliefs about the inferiority of Black people [27]. These beliefs permeate all areas of higher education, namely STEM education [28]. Engineering as a discipline has been studied as a space where the permeation is exacerbated within classrooms and programs due to stereotypes that have shaped what the ideal engineer looks like, where they come from, and what they can do [1], [29].

Nevertheless, engineering majors as we know them today exist within an organization: the university—most ($x > 50\%$) of which originally housed engineering majors exclusively available to white men [30-31]. This further influenced the engineering culture to be selective and exclusive at its inception. Still, many Black students face the selective and exclusive nature of engineering at PWIs. It is imperative to understand that this culture affects Black students' experiences and, consequently, their thriving process.

Engineering Culture

In Fleming et al.'s study on engineering identity [11], Black students were affirmed in the engineering culture at their university, which led them to (1) welcome rigor as a contributor to their intelligence, (2) feel a sense of belonging in engineering, (3) have a strong will to succeed, and (4) not experience significant tradeoffs between who they are and whom they need to be in engineering. They were thriving. This study further supports the necessity of an environment reinforcing Blackness for Black students, as the Black students in this study were from MSIs. It is important to note that for most studies investigating the experiences of Black students at PWIs, the findings of Fleming et al. [11] are not evident. The engineering culture at PWIs must reinforce Blackness to affect the thriving process for Black students positively. Studies have found that Black students excel despite the traditionally stifling engineering cultures they endure at PWIs, but have limited enjoyable experiences. Few Black students can function well and feel good in their engineering programs. They often lean on embedded safe spaces such as the National Society of Black Engineers (NSBE) or Minority Engineering Programs (MEPs) to develop an external proxy environment where they find advocacy, agency, a sense of belonging, and community [5-6], [33-34]. These spaces are traditionally housed within engineering programs and struggle to influence the engineering culture. Policies, traditions, and access are all outputs of the engineering culture at a university. Thus all interactions between students, faculty, administration, and staff are governed by the beliefs found within this culture. Interactions characterize the external environment by being vehicles of accepted cultural practices.

Placement

My decision to visualize the external environment of BSTiE as the outside enclosure of thriving was intentional. The engineering culture at PWIs impacts Black students' motivation, competence, belongingness, and assimilation. Unlike the internal environment, the external environment shapes the

other constructs of thriving by providing a culture that governs how engineering is presented at a university.

Implications & Limitations

In my previous publication, I called to action stakeholders of engineering programs at PWIs:

> *"It is no longer feasible for students to "wait on the world to change" in external environments that perpetuate negative experiences. Stakeholders of engineering programs must take stock of the state of their culture and assess if the environment they have cultivated is conducive to the diversity goals they set out at the onset of every academic year."*

This statement still holds today. The content of this paper further proves that the responsibility must be shifted to the power-holding stakeholders of engineering programs. Much research has identified how Black students experience engineering. While all experiences differ, most Black students' reported experiences have been negative. However, for decades, institutions have directed efforts toward enhancing experiences for marginalized students on their campuses and in specific programs. It is time to reconsider the efforts in place. BSTiE provides a much-needed lens to understand the constructs at play when Black students attempt to thrive at PWIs. While Black students need to have a sense of self-awareness of their thriving, it is even more critical for PWIs to understand their role in facilitating or inhibiting thriving for Black students in engineering. Engineering colleges at PWIs need to assess the culture of their programs to ensure they can facilitate thriving for Black students.

BSTiE conceptualizes the factors affecting thriving for Black students in engineering programs at PWIs in America. Thriving is a concept that is heavily dependent on context. This dependency limits the generalizability of BSTiE to other communities. Nevertheless, BSTiE serves as a building block and motivation toward understanding the thriving process for Hispanic students in engineering programs at PWIs, Native American students in engineering programs at PWIs, and other marginalized communities.

Future Work

A limited body of work studies the university's role in facilitating thriving for Black students. This paper is a foundation to emphasize the need to look towards the university when considering how Black student experiences can be enhanced. We aim to build on this foundation by studying institutional support for thriving spaces for Black students. We plan to explore how universities can best support MEPs as pre-designated places of thriving for Black students. We acknowledge that MEPs are not always places of thriving for all Black students. We have chosen to focus on MEPs because many studies have shown they can have a positive effect on the thriving process of Black students by giving them a stronger sense of belonging, helping them to feel more competent through tutoring and recognition, motivating them through representative faculty participation and staffing, and giving them a space where they can be stripped of assimilative expectations [32-34].

We will conduct a qualitative descriptive case study through the lens of Ray's [35] Theory of Racialized Organizations to investigate how a historically White institution enacts support for a race-conscious MEP. We leverage the Theory of Racialized Organizations to establish the university as a racialized organization and, thus, a product of a racial ideology and structure. The use of Ray's Theory of Racialized Organizations will further our understanding of how the external environment identified in BSTiE is influenced and governed by a racialized organization, the university. Viewing the university as a racialized

organization will reveal how resources are distributed along racial lines supported through engineering cultures in the external environment.

Moving forward, we urge researchers to shift from investigating student experiences to investigating how institutions can enhance student experiences. As seen throughout this paper, the negative experiences of Black students have been studied in multiple ways. These studies all point to the crucial role of the university in shaping student experiences. Universities are responsible for enforcing environments conducive to their students' thriving process. Research studies on student experiences should begin to hold universities accountable for this responsibility.

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