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Black Men in the Making: Engaging in makerspaces promotes agency and identity for Black males in engineering

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An Investigation of the Engagement of Black Men in Engineering Academic Makerspaces

Abstract

Thought must be given to how individuals from underrepresented groups (URGs) conceptualize their academic engineering identities. Black male students have been shown to face a great challenge in integrating their racial identification into their self-concept. This "balancing act" involves the navigation and negotiation between multiple social spaces. The establishment of a positive identity associated with engineering is critical to how underrepresented students establish their sense of agency and overall "fit" within the institutional and/or professional setting. Yet, because of low numbers in participant populations, many studies fail to disaggregate the experiences of individuals from URGs. Further, if makerspaces represent an avenue of hope for fostering a generation of makers and innovative thinkers prepared to address the needs and challenges of our society, it is quite plausible that without careful attention we could be building another exclusionary system through makerspaces, grounded in the acceptance of Caucasian, male experiences and perceptions as the status quo. As making could potentially impact academic progression, through early exposure and opportunities to develop confidence through building, design, iteration and community, it is critical that we understand how all students, especially those from underrepresented groups, come to affiliate with, become alienated from and/or negotiate the cultural norms within these maker communities. To achieve this, it is necessary to explore the complexities of underrepresented students' identity development. This study investigated the experiences of Black male engineering students that have also engaged in university-affiliated makerspaces as makers. Seven Black male students from a range of institution types, including Predominantly White Institutions (PWIs), Historically Black Colleges and Universities (HBCUs) and Asian American Native American Pacific Islander Institutions (AANAPI), participated in narrative interviews to ascertain stories of their personal growth and identity development. Engaging in makerspaces was found to promote agency and engineering identity for Black male undergraduates; however, makerspaces located at PWIs were found to reflect the heteronormative culture of engineering in a way that challenged smooth navigation in and through these spaces for Black men.

Introduction

As a White, male dominated field, increasing diversity has been a prevalent issue in engineering for many years. Though students enrolled in engineering programs may find themselves immersed in an engineering environment, the development of professional identities does not happen as readily and has been cited as one of the main barriers facing students from underrepresented groups pursuing higher education. According to Marra et al., feeling a lack of belonging in engineering is one of the largest factors influencing a student's decision to leave engineering [1]. This can often be exacerbated for underrepresented students when compounded with existing structural and systematic issues such as the lack of visible professional role models, exposure and/or access to science, technology, engineering and math (STEM), under-resourced public schools and inadequate preparation to matriculate into a university-level engineering program. Efforts to answer the call to increase diversity and inclusion in engineering should start with an understanding of how people from groups marginalized in engineering experience engineering. Experiences in engineering include reception to the curriculum, classroom dynamics, interactions with professors and peers, and engagement in co-curricular and extracurricular activities, among others. University-affiliated makerspaces have gained

widespread adoption with the hope of positively impacting successful outcomes among the students that use them. However, it is unknown whether these spaces—where students might participate as a requirement for a course, as an activity associated with a specific club or to develop prototypes for their entrepreneurial pursuits—perpetuate existing heteronormative (White, male, heterosexual, middle/working class dominated) cultures common to engineering. Makerspaces value individuals having freedom and flexibility with regard to the space, but are better defined by what happens in the space and how people experience it [2]. If makerspaces represent the potential for cultivating a generation of makers and innovative thinkers prepared to address the needs and challenges of our society, it is quite plausible that without careful attention we could be building another exclusionary system, grounded in the acceptance of White, male experiences and perceptions as the status quo. This work seeks to specifically focus on the narratives of one understudied demographic in engineering—Black male engineering undergraduate students—to understand whether experiences in engineering academic makerspaces foster development of their engineering identities.

Literature Review

Makerspaces

Engineering industry demands have evolved requiring those in the profession to possess a comprehensive set of skills that involve more than technical competence alone [3]. These recent and persistent industry demands coupled with the availability of affordable prototyping equipment have spurred the growth of makerspaces [4]. Specifically, in higher education, former President Obama's support to foster a generation of makers has catalyzed hundreds of universities to make institutional commitments to promoting the maker culture, commonly demonstrated in the enhancement or establishment of university-affiliated makerspaces [3]. Making is widely embraced for the informal, hands-on, iterative, collaborative experiences in building, creating and designing that it affords. Hence, Makerspaces are places of innovation, creativity, and exploring curiosity through hands-on learning experiences. While 3-D printers, laser cutters, and other computer aided design tools housed in a makerspace are not different from that of the equipment one would find in a typical machine shop, the culture and interactions unique to makerspaces transcend traditional stigmas. These spaces are established with the hopes of creating American producers, rather than consumers while simultaneously advancing domestic innovation, entrepreneurship, manufacturing and STEM education [3].

University makerspaces are designed and implemented with the implicit intention of creating pathways to increase the quantity, diversity and competence of engineers through introductory design experiences [5]. One of the critical arguments of the benefits of makerspaces is that they establish communities of practice for university student makers as members co-participate in a range of activities [2]. For underrepresented students, and Black males, in particular, forming such communities of practice could promote a sense of belonging that facilitates a prioritized focus on developing as an engineer rather than a focus on developing as a Black, male engineer potentially at the intersection of two or more marginalized identities. Another suggested benefit of makerspaces is its association with the desire to create, build and make, which "associates them with the engineering profession" [6]. It is critical that we understand how all students, and

especially those from underrepresented groups, come to negotiate the cultural norms within these maker communities [7] and the impact that it has on their identity development as engineers.

Identity

Identity is a process of understanding one's self within the larger sociocultural context [8-9]. According to Erikson, identity helps individuals make sense of and find their place in the world. In the 1980's, McAdams extended Erikson's work on identity, arguing that as an individual tells and retells their story and how they fit into the world, they are developing their identity. In other words, our life story and how we know ourselves and how others know us is our identity [10-11]. Within the context of engineering education and professional identity formation, Tonso defined engineering identity as a sense of belonging to the profession [12], which influences one's perception of themselves, others and the profession itself [12-14]. Students begin to identify as engineers if and when the institution recognizes them as being engineers [12], [20]. It is possible that through the hands-on nature of making, students could have an increased opportunity to feel like engineers than one might be afforded in a more theoretical-based classroom environment. A common misconception is that students are blank slates onto which their academic experiences impart complete and monolithic identities; however, in reality, they can be considered cumulative representations of historical, institutional, and sociocultural experiences [15-16]. Only traits consistent with the existing self-conceptions are likely to be adopted into professional identities [17], which makes understanding the experiences of Black male undergraduate students all the more critical as it is directly related to their persistence in engineering and adoption of their professional selves.

Black Men in Engineering

Black undergraduates—males and females combined—received only 3.5% (124,477 total; 3,442 Black males, 1,102 Black females) of the Bachelor's degrees awarded across all engineering disciplines in the academic year 2016-17 [18]. The percentage of degree recipients was just slightly lower than the 4.5% enrolled in engineering in that same academic year [18]. The underrepresentation of this demographic in engineering compared to U.S. population statistics estimating the number of Black Americans to be near 14% speaks to an explicit endemic in engineering and a need to better understand how navigating such environments affects Black students and development of their personal and professional identities. Tate and Linn found students of color to maintain multiple identities as a means of persisting and conforming to social norms in their engineering programs. Three separate and emergent identities were prevalent for underrepresented students: academic, social and intellectual [19]. The context in which underrepresented individuals experience the makerspace environment, in conjunction with the dynamics of their interactions, could impact their identity formation. Thought must be given to how individuals from underrepresented groups conceptualize their academic engineering identities [19], [21-22].

Black male students have been known to uniquely struggle with feelings of condescension, isolation, super visibility and invisibility while attending predominantly White institutions (PWIs) [23] as they deal with problems of presumed incompetence and thus, low expectation. For example, the myth of meritocracy that contradicts known systematic and structural injustices

creates an environment where a student whose school did not have Calculus somehow becomes responsible for not keeping up to the same extent as their more than adequately prepared peers. And yet, this is not recognized as grit, but rather labeled as incompetence, or lack of effort. Additionally, Black male students have been shown to face a great challenge in integrating their racial identification into their self-concept. Specifically, students are faced with the "balancing act" involving the navigation and negotiation between multiple social spaces where what it means to be a Black man may be incongruent with the social norms of other identities [22]. Evidence of this occurs when a Black male student is perceived by his peers as "acting White" when they are in fact being professional [23]. In many instances, there may be misalignment between the personal and societal expectations, which could inhibit the power of specific environments for Black men. Academic achievement has been shown to occur for international students when culture is treated as an asset [24]. Makerspaces that encourage Black males to integrate their culture and ways of knowing could serve to promote their learning and professional development. This study will enable us to explore from the stories of Black male engineering undergraduates how engaging in a university-affiliated makerspace, for this study an engineering academic makerspace specifically, has impacted their personal and professional development, especially when it comes to the differences in the context of institutional culture (i.e. PWI, HBCUs, AANAPIs, HSIs, MSI, etc.).

Theoretical Frameworks

This work will be situated in three theoretical frameworks that contribute to the understanding of Black men in the context of engaging in makerspaces. The selected frameworks also inform the methodological choices of this study to capitalize on the power of story and identity. The frameworks are the ecological systems theory, critical race theory focused on counter-storytelling and narrative identity.

Ecological Systems Theory

Ecological systems theory gives insight on how an individual's environment and overall setting will play into their identity development. The ecological system theory allows for the analysis of an individual with respect to the environment they are directly placed in, such as their neighborhood, household and family, while also considering the macrocosm that is out of their control i.e., the culture of the society in which they are living as well identifying factors of the individual themselves (i.e., race, gender, etc.) [25]. The ecological systems framework can be broken down into 4 different sublevels: the microsystem, mesosystem, exosystem and macrosystem. Though each system will have a significant effect on the identity development of the individual, influences directly to the individual will only take place on the microsystem level, which would be represented by interactions in intimate settings.

The microsystem can be described as settings or environments with which an individual interacts on a regular basis. An example of typical microsystems would include schools, classrooms, offices, laboratories, and even, makerspaces. According to Bailey et al., microsystems can often have different effects on the individual, where each environment brings about a different influence, just as the individual interacts with each environment in a unique way [26].

Critical Race Theory - Counter-storytelling

Critical Race Theory (CRT) is utilized as a framework in studies where racial inequalities in a society are addressed and analyzed, in this case, the White, male dominated field of engineering. CRT was developed in the late 1980's as a response to the slow reform of racial policies that propagated oppressive norms for underrepresented groups, specifically Blacks. This theory recognizes race as an important factor that must be taken into account when analyzing a cultural system, specifically in U.S. society, where the historical injustices ingrained in the culture further perpetuate the cycle of oppression for underrepresented groups [27].

Though there are many tenets of CRT that are useful in identifying racial disparities within an environment—counter storytelling, which elevates the lived experiences of black and brown individuals though narrative personal stories [28]—will be the main tenet utilized for analysis in this study. Counter storytelling often works to challenge a well-known narrative, which may inaccurately or inappropriately portray a situation, by using an "outside" point of view, rather than having the story told by a majority. This helps to avoid justifications of systematic oppression or privilege that may unconsciously come into play for a majority status individual. According to Love [29], majoritarian stories, in the context of education, are specifically crafted to obscure White privilege by using devices such as "fostering invisibility, making assumptions of what is normative and universal, promoting the perspective that schools are neutral and apolitical, promoting the myth of meritocracy, endorsing the notion that there is equal educational opportunity for all, and referencing dominants as 'people' while 'othering' subordinates [29]." Majoritarian stories are often taken to be fact, rather than just a story, so many of these devices are not consciously put into place; however, they do allow for the obscurity of White privilege, and the ways in which rules, policies and procedures still work to oppress people of color. The stories of Black men engaging in makerspaces across the country will provide a narrative of how these experiences impact their engineering identity development.

Narrative Identity Framework

Central to this research project is the concept that people describe and construct their identities through telling their stories [10], [30]. Fundamentally, individuals have a narrative way of thinking [31] and individuals develop their identity through telling and retelling their stories [11]. We focus on experience-centered narratives from our participants as we ascribe to Squire's conception that "experience can, through stories, become part of consciousness [32]." These personal, experience-centered narratives are sequential, meaningful to the participant, represent experiences and display transformation or change [33]. Furthermore, we are undertaking a bildungsroman narrative genre that focuses on participants' stories of their personal growth and their meaning assigned to experiences in their life [34-36]. Through their stories, we aim to develop an understanding of how students are forming their sense of self and their identity as they experience an engineering undergraduate program and engage in makerspaces. In this research, we aligned our project to this narrative identity theoretical framework [10], which informed the methodological approach and was integrated throughout the project.

Research Purpose and Questions

Recently, the creation of engineering-academic makerspaces, those of the university and extensions of the engineering school or entities with the primary intent to serve and be a resource to engineering students, has begun to gain momentum. However, researchers have little understanding of the extent to which engaging in makerspaces impacts identity formation of engineering students. This study is a subset of a larger, national study to investigate the impact of makerspace experiences on the identity formation of engineering students. In this particular study, we took a preliminary investigation into the experiences in makerspaces of a specific demographic, Black male engineering undergraduates. This work was informed by the following research questions:

RQ1: What are the personal growth and identity development stories of black male engineering students who engage in and experience makerspaces? What kinds of lived experiences have led these students to develop their identity as an engineer?

RQ2: What do these stories reveal about inclusive cultural norms in makerspaces?

The work is a novel approach to elevating the voices of students from underrepresented groups, here specifically Black males, whose unique experiences have often been lost in translation due to small numbers.

Methods

Participants

Institutional Review Board approval was granted to complete the study. Engineering undergraduates enrolled at institutions with an engineering-academic makerspace were recruited for participation in the study. Nationally, 67 students participated in the larger study representing South Central (public, Predominantly White Institution (PWI)), Mountain University (public, PWI), Gulf University (public, Hispanic Serving Institution (HSI)), South-Atlantic University (private, Historically Black College and University (HBCU)), Pacific University (public, Asian American Native American Pacific Islander Serving Institution (AANAPI)), New England University (Private, PWI) and Middle-Atlantic University (private, liberal arts college) (pseudonyms chosen to protect identification of any student affiliation to specific universities). Of the total participant population, 15 were Black males, 7 of which were included in this analysis (see Table 1). All participants were compensated for their participation with a $25 Amazon gift card.

Data Collection

In depth, narrative interviews served as the primary data source for this study. Interview questions followed a narrative format and were open-ended to allow the participant to expand on their experiences. The goal of the questions was to encourage the participants to share rich accounts of their experiences as an engineering student and as a maker. Specifically, participants were prompted with the question, “I understand that you are an undergraduate engineering

student and a maker. Could you tell me your story of how you got to where you are today?" This prompt was more than sufficient at eliciting the participant's narrative of how they became who they are today—pointing to their identity formation. Researchers were intentional at conveying a sincere interest in the participant stories to aid in their comfort taking longer turns to develop their story [36]. The duration of the interviews lasted from 30 minutes to 1.5 hours.

Table 1. Participant demographics.

Pseudonym	Year in Engineering	Major	University	Institution Type
Bryan	1	Mechanical Engineering/Physics	South Atlantic University	HBCU
Byron	3	Computer Science	South Atlantic University	HBCU
Brayden	1	Mechanical Engineering	South Atlantic University	HBCU
Bricen	1	Aerospace Engineering	South Atlantic University	HBCU
Barrett	4	Mechanical Engineering	Central Pacific University	AANAPI
Blake	3	Electrical Engineering	North Eastern University	PWI
Bryce	2	General Engineering	Mountain University	PWI

Data Analysis

This study used a qualitative research design, specifically a narrative approach [37]. As Polkinghorne (1995) stated, "narrative is the linguistic form uniquely suited for displaying human existence as situated action" (p.5). The narrative approach serves as "a means through which those who have been historically marginalized can be heard" [38]. The narrative method applied in this particular study aligns well with the critical race theory lens which urges the counter-storying of people whose experiences are not often told as marginalized individuals in various sectors, here, engineering and makerspace environments. These stories challenge the majoritarian stories and have long served as a tool for the liberation and survival of the oppressed [38].

Students described their stories thoroughly often going as far back as childhood to talking through to their current courses and experiences in engineering and making. The focus for this work was to understand how engaging in makerspaces impacted the identity formation of Black male engineering undergraduates. We first developed a codebook of 10 codes related to the project's overarching research questions around identity formation, makerspaces and underrepresented students. The codes included "experiences that shape identity," "road of trials in engineering," "stories of values, knowledge, skills, practices and norms in engineering," "stories of bias, prejudice and stereotype," "recommendations for makerspaces," "pathways to engineering" and "aspirations, goals, desires or plans." These deductive codes developed as a provisional "start list" served as the first-cycle coding [39].

Though all of the codes proved useful in establishing meaning, two of the codes became the focal points for understanding unique aspects of these students' experiences in makerspaces: stories of values, knowledge, skills, practices and norms in makerspaces, and stories of bias, prejudice and stereotype. Stories of values, knowledge, skills, practices and norms in makerspaces referred to articulated characteristics that distinguished makerspaces from

engineering classrooms, while stories of bias, prejudice and stereotype, on the other hand, provided insight into the culture of engineering and associated academic makerspaces across different types of universities. The data shared here describe the analysis of the excerpts attached to these two codes. The preliminary effort was to observe the prevalence of any patterns that could then be applied in a second-cycle analysis of a larger pool of Black male participants. The intention was to understand whether makerspaces produce an environment where Black males thrive as well as to identify the unique attributes that facilitate this, if present.

Findings

A major finding of this study begins with the identification of Black men navigating engineering-academic makerspaces. This was a nationally conducted study. A total of 10 separate engineering-academic makerspaces at 7 institutions across the United States were visited where interviews were conducted with 67 students. Similar approaches to engaging with students present in the makerspace were taken at each institution. Research team members spent a total of three days at sites to minimize the artifact of a particular day being "a bad day" to catch students in the makerspace. Additionally, makerspace administrators had advance notice of our scheduled visits as well as project interests and thus encouraged students that regularly utilized the spaces to make their way in at some point over the course of our visit. Despite this, only 15 (22% of all participants) Black men were encountered across all of the makerspaces. This percentage is not low when the demographics of Black males in engineering are considered. However, the fact that 12 of these 15 participants were encountered at one institution that happened to be an HBCU meant that only 3 of the 55 students encountered across the other 6 institutions were Black men. Though it may seem as if the study is skewed by having such a large representation of Black males at one institution, it represents the presence of Black males engaging in engineering-academic makerspaces being low across the profile of institutions included in this study, which were strategically selected to represent a cross-section of the engineering institutions diverse in size, profile and region, nationally. It is possible that this is just a manifestation of the existing demographics of engineering. However, this is counter to the assumption originally held by the research team that anticipated if makerspaces were found to perpetuate a more inclusive culture, there would be an overrepresentation of underrepresented students engaging in the environment, and in this case, Black men, compared to engineering classrooms and enrollment.

Through narrative, the objective is to retell the stories of the participants and recognize the commonalities of the experiences across participants. The significance of this study is an opportunity to explore the counter-story, the experiences of those from marginalized groups navigating engineering and makerspaces that is less commonly the driving voice. The length of constructed narratives makes it difficult for them to be included in manuscripts. However, to effectively provide a feel of this study's participant stories and their experiences, an excerpt from one participant's, Barrett, 1st person constructed narrative will be presented here. The remaining participant stories will be integrated into the subsequent section that presents the findings and themes embedded in discussion of the literature and interpretation of related theory.

> So, some of those opportunities, I told them I just can't do it, with my course load ... But I also feel like maybe some of the professors I wanted to maybe work under, maybe I just wasn't able to ... I don't know, I just wasn't able to really reach

out to them, I felt like…I felt like they weren't really looking my way. Maybe not so much in the maker spaces. As a student, probably so, people are just hesitant to ... I don't know if [it's] because I'm older or it's because I'm black. But, I think even with my first degree, there was ... you know I was a little bit, it was a little bit harder to take me in as a ... as one of their friends. And I don't know ... yeah, I can just say that yeah, across the board, throughout my long life in school [that was the case] ... I would have to be, if say I were integrated I could probably ... if I didn't express myself, if I didn't take initiative to talk to somebody I'd probably not know very many people in my program. I could see that happening. And I think that one or two semesters, that's happened before. Definitely. And I don't know if that's just because, you know my ethnicity, or it's because of my personality. But, I feel like it has something to do with my ethnicity. That's just the, I can't really place it, but I think it's there. It's hard not to see me, I'm standing out, I'm the only black guy in the class. With dreadlocks …But at the same time, like as far as a student that they would depend on for work, I don't know if they're looking my way, that's what I mean. So, that's all I can say about that.

I've grown up here too long, [to say that racism does not exist here] is not the case …Yeah, your sample size is, yeah anybody who's lived here for twenty years knows that racism definitely exists. It's just subtle. Yeah, that's - I mean people, I mean for one, you're kind of in a bubble in [here]. In some ways, it's kind of strange, you have all different people coming here. In other ways, people, still carry these - they go on with the stereotypes.

I've only seen one example of that happening, and it's kind of hard because I'm not in the snap chats, you know I don't really know what's going on. But, I've heard about some of the snap chats and one of them was, you know, was obviously making fun of this person, you know. And, then I've also seen it with ages, older students, you know. There like "Oh this guy, you know, he's just being uncle or grandpa." Or you know "He forgot this." Or that kind of stuff. So that definitely happens ... and I also feel like, in the ageism part, some students will talk up to you. So, that's kind of interesting. But, yeah those are the only things that I can really, speak on. Most of my time is not spent on campus it's spent in the lab. So, I only have a small sample size. I barely know what's going on. I mean just this past semester, I think it was last semester I think was the first time I went to a theater show so ... and its only because I'm in a theater class now.

For faculty, ... admittedly I'm not an A student. I work hard on what I do, but I don't always get the best grades. The thing is that, when professors see those students, they assume that they're just playing around and I understand that you know like, "Why can't you do this stuff that I did in my sleep." I think, there's a lot of extra work that I've had to do in order to get to where I need to be, and beyond. So, I think it's important that, whenever a professor's talking to you about, like your opportunity as a student or what you might want to do with them, that you know they convey that it's okay that you're having a hard time or ... it's

> okay that you're having a hard time it's not unusual, but maybe ... where do you feel your strengths are?
>
> I think when I first went into college as a ... you know from high school, granted I probably wasn't as focused as I am now, but at the same time, I felt that, it was assumed that I wouldn't work hard at what I was doing for this, that and the other. Maybe I looked like a typical athlete when I came into the program, which is one thing in itself. So, I think it's just important that they're able to at least dig for that student's strength. That's kind of easier said than done. So, and yeah that's all I can say about that.

Findings in Context

Maltese, Simpson and Anderson quoted a maker educator commenting on his experiences in a makerspace as saying:

> I have noticed that many of the strongest students academically and who are considered to be 'smart' by their peers often struggle more in creative problem-solving situations. The opposite is often true of many students who are not what is considered 'traditionally smart.' These students excel in a maker context.
>
> - A Maker Educator

This quote could be directly applied to Black men in making, considering they are often discounted as being less that exceptional students, and often have been documented as struggling in traditional classes. As traditional learning approaches are not widely known for their success at establishing engineering identity for Black males, engaging in makerspaces offers a potential opportunity to have more positive results in facilitating this identity development. The participants in this study described their engagement in makerspaces as a solidifying agent in their decision to pursue engineering as well as pivotal in the development of their abilities to persist and thrive within engineering. Makerspaces offer a very specific set of properties that allow for learning to come in different capacities based on the person and makerspace. The Black males interviewed in this study, who have participated in makerspaces during their time as engineering students, reported many positive takeaways from their experiences in makerspaces.

Value of Creating

> I get to make things, I get to see things. I get to see my ideas actually before I can create it.
>
> –Bryan

Participation in makerspaces creates an environment in which learning is more fulfilling because it allows for expression of creativity, critical thinking and use of a more in-depth design/ideation process. One of the largest shared values of the participants unique to the makerspaces was the ability to visualize difficult concepts while trying to understand them. Makerspaces allow for students to physically see a process and progress from ideation to creation, rather than just a written report or CAD drawing that would serve as typical deliverables in a classroom setting.

Brayden commented that before he had access to the makerspace, he was only able to use AutoCAD and SolidWorks to design his ideas. But, now he is able to produce something tangible to substantiate feasibility and iterate through prototyping. Through his experiences in the makerspace, he was "learning so much in that process from taking it from a CAD [model], putting it into the 3D printing [software and] configuring it so that it can print correctly." These students often value the fact that they are able to visually see the different steps of completion on a project, something that is rarely seen in traditional classroom approaches. Makerspaces give participants a sense of ownership over their intellectual property, specifically because they are able to make their ideas into tangibles. This enables students who engage in makerspaces an opportunity to validate their ideas since they are able to physically see them as well as different problems that arise in the design process.

Real World Applications of Engineering Process

In engineering courses, many of the lecture format classes present problems that are idealized, with a set of assumptions in order to make it as simple as possible. While this is an adequate way of teaching concepts, often these assumptions will not hold in reality, causing processes to shift, and the overall problem to become much more complex. This is one of the lessons that makerspaces are able to convey much more effectively than classroom learning. Brayden, while in his last year working in the maker studio at the National Institutes of Health (NIH), indicated that he was able to learn "about the small things in engineering, the small things in fabrication that really can make the biggest difference." Unlike the problems that are presented in classrooms, here, Brayden was able to participate in the physical aspects of engineering activities, where he is able to have real experiences without the luxuries of assumptions and clean calculations. Brayden had his first taste of engineering through his time in the maker community at NIH, but he was able to see the engineering process first hand through his mentors during his time working there:

> And I'm thinking to myself, this is really what engineering is, whether it's a bandsaw, or this expensive unique piece of equipment, it's really just going into it. Even the bandsaw, back when I saw Doug and Ryan working on it, they had no idea what they were getting into when they opened it up, but after opening it up and taking it out, they were just solving problems as they came across it.

Brayden's definition of engineering favors the concept of comfort with ambiguity. In a given situation where the standardized process or approach is unknown, being an engineer is having the confidence to move forward and solve problems as they arise. Brayden learned that engineering is not automatically knowing what to do in every situation and that for him was a paradigm shift in his thinking. Through this exposure of watching his mentors essentially reverse engineer multiple bandsaws on the fly, he was able to learn about and experience the engineering design process on a much more intimate level than what is commonly afforded in the engineering classroom environment. This was counterintuitive for most of the participants that came into engineering expecting to have these types of hands-on learning experiences by actually doing engineering in their classroom rather than being faced with more theoretical approaches to learning.

While they are known as a place to develop technical skills, engineering makerspaces are often places where students can learn, practice and directly implement aspects of the engineering design process. Bryan displayed an enthusiasm for the development of skills beyond those in focus which was captured in his statement, “Wow, these options that were available to me, they helped me in such a way that now I have these sets of skills that aren't necessarily focused on, but are still important. Like, when I came to this visualization and drawing, just being able to have an idea and draw it out, that's a huge thing.” Engaging in the makerspace seems to elucidate hidden value of experience while building the knowledge and confidence as an engineer for these students.

Interpersonal Communication Skills

Making culture often transcends the physical space and is meant to create a feeling of comfort and excitement when approaching innovation, creation, tinkering and/or development. This making culture helps to drive students to greater heights as they not only challenge themselves, but also challenge each other to get better and go higher. One of the main staples of the making culture is the idea of collaboration. Through the combination of many different minds, a solution can eventually be reached through iterative tinkering and diversity of thought. The makerspace environment allows for Black men makers to interact with other makers within the space to share ideas and work collaboratively to develop novel solutions to many problems. Bricen described the comradery of the space, “Kind [of] been a neat transition meeting other people who have similar interests as me and want to go and make things. Which was always cool. Sharing ideas, bouncing things off other people.” Depending on the context of the project being worked on, makerspaces offer opportunities to work on skills beyond prototyping. Brayden, while working within the NIH maker community, had the opportunity to interact with researchers who were using the monkey chairs he was assigned to repair. This gave him a chance to fine tune his interpersonal communication skills, since he would have to work closely and communicate with the researchers to make sure he was designing to the correct specifications.

Makerspaces are open environments that attract people from many different backgrounds and skill levels. Byron has seen many different types of people utilize the makerspace in order to take advantage of the creative thought processes that are attracted. As a staff member of the makerspace at the HBCU, Byron has witnessed a range of different disciplines using the makerspace such as music professors, sociology professors and “business majors [who] have ideas” that “find their people who they want to work with and build their project from.” In order to work with these different disciplines within the makerspace, participants must be able to clearly articulate and convey their ideas across a variety of audiences. In this sense, makerspaces, through their collaborative culture and multidisciplinary consumers help to develop and/or hone soft skills that are also a necessary component to succeeding as an engineer.

Superior Learning Experience Relative to Traditional Approaches

Many of the participants referred to their experiences in the makerspace as being much more rewarding in terms of knowledge than a lecture style class because it allows for a direct application of theory rather than abstract knowledge being presented. In describing that the classroom did not provide the same exposure, Byron stated, “In the lab, you have to do a lot of

outside research to find out what you need to do. No one is telling you what to do step by step. It's a very creative [space]. Inside the classroom, the same creativity isn't necessarily used." Shortly after, he reflected on the effect that the project process had on his ability to design and make, stating, "Basically, it taught me how to break things down into parts in my head, and that makes it so much simpler." Due to his ability to apply the concepts learned in class to the maker-projects he was simultaneously working on, Bryan considered the effect of his experiences in the makerspace when he said, "I was more excited to go to school, after I started getting involved in making. Even when it came to different science courses, they seemed to have more importance to me then." Not only do makerspaces teach valuable lessons and skills relevant to engineering, they also enhance the effectiveness of traditional classroom teaching approaches by allowing students to engage with classes on a deeper level, as in the case with Bryan.

Reflective in Culture

For the HBCU in this study, the makerspace was used to conduct a summer bridge activity for incoming first year students. In addition to gaining exposure to hands-on projects, designing and building, the students had the opportunity to engage in projects that involved culturally relevant applications, i.e. creating an African drum using specialized materials and studying the engineering involved in the acoustics. Students had pride for what they made and were extremely receptive to makerspace applications that had other connections to aspects of their identity. This early exposure to the makerspace served students not only by introducing them to the way of learning in that space, but also served to enable the students to create a sense of community prior to their official start at the university. It is worth noting that the makerspace at South Atlantic University had a large number of first year Black men students engaging in the makerspace compared to other institutions. This may demonstrate the mechanism by which students come to experience the makerspace having a significant impact on the way and/or frequency that they engage with it moving forward. Blake, who attended North Eastern University, a PWI, was briefly introduced to the makerspace through his initial campus tour when he was able to "get a quick overview of it", and later only engaged in the makerspace through his own initiative. From the provided example, the HBCU was intentional in using the makerspace to transition into the university while also encouraging their engagement in the makerspace. Perhaps this is something that should be further explored considering the potential positive outcomes associated with navigating in the makerspace. Students should not have to serendipitously encounter the makerspaces and there is opportunity to be more strategic with respect to initiating engagement in makerspaces, especially for underrepresented students.

Conflicting Cultural Immersions

Through the stories of the various participants, a difference in the cultures of engineering makerspaces was revealed. Reflecting on his past experiences at NIH, Brayden explains his reasoning behind choosing to attend an HBCU, which was closely related to seeking a culture closer to his own:

> I came to [South Atlantic University] because I felt like it was deeply rooted in Afrocentric teachings, and Afrocentric thought, and I thought that was important, because I've been looking from a European perspective for a longtime. But now,

> to see the world from an Afrocentric perspective, or see problems and issues from an Afrocentric perspective, I guess that influences my train of thought, and if it influences my train of thought, it influences it in STEM, too.

The difference in culture between the two spaces was made clear here. Brayden chose to attend an HBCU because of a difference in culture from the environment that he was coming from. The culture of the makerspace is potentially influenced by the culture of the institution under which it is housed. This will be further explored in future work. However, in this case, the culture of the makerspace was well suited to facilitate involvement in the makerspace for Brayden because it aligned with his own culture. However, the opposite can be observed when the culture is not in alignment with that of a student, and this, as Tonso stated, creates a barrier to developing the identity—be it of a maker, an engineer or any other identity [12]. Blake, a junior at a North Eastern University, a PWI, explicitly described his experience as different from his majoritarian peers, indicating that other participants in the makerspace "might not necessarily ask me for assistance first versus somebody else unless they're like, 'oh, no he knows how to do it." He continued to clarify that by somebody else, he was talking about "someone who doesn't look like [him]." This constant underestimation of his skill level based on his appearance was a constant reminder that he was different. It was this created awareness that not only was he Black within the space that is traditionally not inclusive for him, but also constantly underestimated and deemed incompetent simply for being so. This microinsult in an ascription of intelligence was communicated across many of the stories of these Black men participants and often resulted in their need to feel they had to prove themselves in all spaces.

A similar dissonance was observed in the experience of Barrett, a fourth-year senior who studied at an Asian American and Native American Pacific Islander-serving institution (AANAPI). When asked about his experience in the makerspace, he indicated that he was having trouble engaging with people, though he was not sure of the true reason behind it:

> I don't know if [it's] because I'm older or it's because I'm Black. But, I think even with my first degree, there was ... you know, I was a little bit, it was a little bit harder to take me in as a ... as one of their friends. And I don't know ... yeah, I can just say that yeah, across the board, throughout my long life in school [that has been the case]...

Here, Barrett was alienated from the rest of his classmates due to his inability to connect with them. He was at odds with the culture of his institution, which affected his ability to fully experience the community within the makerspace. When trying to explain his feeling of isolation, he comments "I feel like it has something to do with my ethnicity. That's just the, I can't really place it, but I think it's there."

Conclusion

The experiences in makerspaces and values of making among these Black male engineering undergraduates show promise. However, there are still signs that there are issues that must be addressed. Engaging in the makerspaces proved to be an experience that enabled the development of skills, confidence, comfort with ambiguity and failure in ways that seem to be

limited in traditional classroom settings. The focus of this study was primarily to investigate whether makerspaces promoted the identity formation of engineering students and to investigate the cultural norms of makerspaces and how they support inclusion. This preliminary analysis of a subset of Black male engineering students provides evidence of positive attributes to making that support successful outcomes for engineering students. The cultures of the makerspaces in this study differed based on the culture of the institution under which it was housed. This greatly affected the ability of Black students at institutions outside of HBCUs to feel like they were an integral part of the space despite many of the positive factors that came from participation in the makerspaces.

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