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A Limited Look at the Educational Experiences of Black STEM Professionals from the Butler Community and Beyond

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Abstract

This project looks at the STEM educational experiences of Black professionals from both the Butler community and outside of it. It focuses on the perspectives of five individuals (three Butler graduates and two non-Butler graduates) interviewed via Zoom and analyzes how their experiences compare to those of other Black STEM professionals across the nation. After completing the interviews and conducting thorough background research, all data was examined. It was found that what was discussed during the interviews paralleled what was discovered in the research, such as the importance of mentors and broadening the image of what a scientist looks like. In conclusion, there is some work being done by various organizations to combat the systemic racism we see in the STEM field, but we must continue this work in order to dismantle it.

Introduction

Racism, or the discrimination and prejudice against a group of people based solely on their racial or ethnic group, is the cause of racial disparities throughout the world. This discrimination is present in all aspects of life. One example is education, specifically for those pursuing a STEM degree. STEM professionals have always been an important part of our society, but the need for them has grown, especially in recent years, with the increased prevalence of technology. Computer occupations are in high demand and are partially responsible for the increase in STEM employment. Computer occupations as a group are projected to grow about three times as fast as the national average for all occupations between 2019 and 2029 at 11.5%; this will result in more than

half a million new computer jobs over a ten-year period (Zilberman & Ice, 2021). As we become more reliant on digital devices and the importance of data increases, there is also a greater need for data security as the digital economy continues to grow at a rapid rate. In 2019, businesses and institutions disclosed 7,098 breaches, which led to 15.1 billion records compromised, according to Risk Based Security; this was a 284% increase from 2018 (Zilberman & Ice, 2021). This is just one STEM profession, but it can be seen that there is a need for more STEM professionals.

Multiple works have looked at differences in the treatment of Black students and professionals, specifically in STEM, and the challenges they face. Even though many Americans view racial and ethnic diversity in the workplace as important, Black professionals are underrepresented in science, and this hurts our STEM workforce. Nearly half, 45%, of US adults say having racial and ethnic diversity in the workplace helps provide other perspectives that contribute to the overall success of companies and organizations, and 45% also say that it gives people an equal opportunity to succeed (Funk & Parker, 2019). Even though this is the feeling of many workers, there is still underrepresentation and discrimination in the workplace. A majority, 62%, of Blacks in STEM say they have experienced discrimination at work; 45% reported they have had someone treat them as not competent because of their race, and 29% have felt isolated in their workplace (Funk & Parker, 2019). Even looking higher up than employment, Black STEM professionals miss out on awards and accolades. In the 120 years since the Nobel Prize was first given out, only 3% of the science awardees have been women and zero of the 617 laureates have been Black, which means the majority of now-famous role model scientists are White men (Zimmer, 2020). These statistics send the wrong message to

anyone paying attention to the field of science. Having an equal and racially diverse environment benefits not only STEM institutions but also the people they are filled with.

Going along with treatment in the workplace, differences in salaries have also been noted. The American Chemical Society (ACS) salary survey returned in April 2019 with 5,121 responses from ACS members. Although salaries varied depending on where respondents worked and even though they had increased since the last survey in 2016, when adjusted for inflation, salaries have been flat since 1982 (Widener, 2019). This statement is true for all those who reported with Doctorate, Master's, and Bachelor's degrees. Looking at the demographics of those who responded, there was startling information. For race, respondents were predominantly White at 84.4% of responses, compared to only 1.9% of responses coming from Black ACS members (Widener, 2019). As for gender, numbers were also not equal. Looking at the 2019 data, men made significantly more than women ($110,000 versus $83,050), and men significantly outnumbered women in faculty positions, especially in the role of full professor (68.9% versus 30.6%) (Widener, 2019). Just looking at this data reported by members of the ACS, it is easy to see that there are discrepancies in the treatment of STEM professionals.

Even before Black professionals make it into the STEM workforce, they must obtain an education for most positions. Minority students are less likely to enter STEM fields and less likely to stay in their declared STEM major; discrimination and bias are a couple of the possible reasons that students are discouraged from pursuing STEM degrees. Over half, 52%, of Black professionals with a STEM job say a major reason for this underrepresentation is because Blacks are less likely to have access to quality education that prepares them for these fields, and 45% attribute these disparities to not

being encouraged at an early age to pursue STEM-related subjects (Funk & Parker, 2019). These reasons lead to what is known as the "leaky pipeline" in STEM, which is a metaphor used to describe the loss of minority students during the pursuit of a STEM career. With 13.4% being the percentage of first-year US college students who are Black, 7.9% is the proportion of US chemistry bachelor's degree recipients who are Black, and only 4.6% of US chemistry graduate students are Black; at US top 50 schools, only 1.6% of chemistry professors are Black (Widener, 2020). This shows that the numbers are low to begin with for Black students pursuing a STEM degree, but they become even more disproportionate as students progress in the STEM field.

The leaky pipeline especially affects women of color. Overall, the amount of STEM women faculty has increased, but women of color faculty (WOCF) has decreased. WOCF make up only 5.1% of non-tenure-track faculty and 2.3% of tenure-track or tenured faculty, and they are more likely to be employed in less prestigious university settings (Liu et al., 2019). They are placed in a "double bind" because they have the minority statuses of being both female and non-White, which leads to unique challenges in academic systems that often rely on subjective perceptions of fit and likability. WOCF often feel invisible and isolated in their departments, that they are not given the same opportunities to contribute, and that they have few meaningful mentoring relationships (Liu et al., 2019). They have to avoid conforming to the "angry Black woman trope", even though students and colleagues are more likely to challenge their expertise. Even when they are mistreated, WOCF are expected to not rock the boat of STEM academia due to cultural norms that socialize girls to "play nice" as children, which continues into the workplace. The greater levels of subtle workplace discrimination that WOCF

experience is worse due to its ambiguity because it causes increased mental ruminaton and allows perpetrators to justify their actions (Liu et al., 2019). This has been shown to have lasting personal and professional repercussions for the targets of this behavior, making them more likely to leave the STEM field.

This project focuses on five individual educational experiences of STEM Black professionals from Butler and other undergraduate institutions and compares them to the experiences of others across the nation. Along with the interviews, background research was conducted. In comparing the personal testimonies of those interviewed to the national data and stories of others, similarities will be found in the narratives conveyed; Black people are underrepresented in the STEM field, and it is important to look at why this disparity occurs in order to remedy it.

Background Research

A wide variety of previous work exists on STEM education and its shortcomings. One common theme discovered throughout research is the lack of STEM opportunities for Black students early in their education, leading to a "leaky" pipeline and retention problems. This is problematic for the STEM community because it needs a diverse pipeline. More diversity in the pipeline brings unique perspectives, ideas, and experiences to the table and leads to a healthy economy and globally competitive marketplace (Casto & Williams, 2020). Retention issues in the pipeline are seen as early as elementary school and can continue into undergraduate and graduate programs.

One example that leads to this is less opportunities for some Black students to get engaged in STEM. It was discovered that the racial segregation between suburbs and cities leads to White people hoarding the best educational opportunities, and STEM

postsecondary fields are a site of racial opportunity hoarding among those who enter college (Riegle-Crumb et al., 2019). STEM-related occupations are seen as more important and prestigious, and they typically are associated with higher lifetime earnings. This perceived value is why the opportunity hoarding occurs. The high schools in lower socioeconomic neighborhoods are limited in the courses they can offer; they are legally mandated to provide core courses, so advanced courses often get neglected (Casto & Williams, 2020). This can even affect younger students. Not having the opportunity to engage in STEM-related learning projects in Pre-K and kindergarten classrooms can limit students' awareness of STEM courses and careers (Casto & Williams, 2020). The lack of opportunities not only affects the children's education but also how they perceive themselves. Family sociodemographic contexts and urbanicity are related to youth's ability beliefs and academic achievement (Seo et al., 2019). Not getting involved in STEM learning at a young age can be detrimental to the education of these students.

If Black students are given equal opportunities and become interested in STEM, it seems to be traced back to one subject: mathematics. It is believed that for the leaky pipeline the attrition in these fields starts from adolescence when young individuals start to lose their motivation toward mathematics (Seo et al., 2019). Despite interest in mathematics or other STEM courses, there is still the systemic issue of racial disparity in the pipeline, and underrepresented minorities (URM) are not being admitted into the STEM pipeline at the same rate as White peers (Casto & Williams, 2020). As it can be seen from this data, this aspect puts Black youth at a disadvantage early in their education.

At the collegiate level, it has been found that undergraduate research experiences (URE) play an important role in this pipeline for URM students. URM students have a harder time obtaining research opportunities, and they are expected to work harder to overrule institutional norms. Overall, 44.8% of students consider leaving URE, but White students are 2.1 times more likely than URM students to report choosing to stay in research because they enjoy their everyday tasks; URM students are also 2.6 times more likely than White students to consider leaving research because they are not gaining important skills or knowledge (Cooper et al., 2019). One of the main reasons students report leaving URE is due to a negative lab environment. This includes unfairness in the lab or being treated differently, less social support or not connecting with others, and feeling excluded or like they were not making significant contributions to the lab. It was reported that students who felt that their lab environment was negative were 1.6 times more likely to choose to leave their URE (Cooper et al., 2019).

Looking at undergraduate Black students in a STEM major, there has been research conducted on the rate at which they leave their majors and reasons why. According to the United States Bureau of Labor Statistics, employment in STEM occupations grew 10.5% from 2009 to 2015, while non-STEM occupations grew 5.2%, but despite this jump, there is a declining rate of STEM undergraduate degrees being awarded to students of all races (Casto & Williams, 2020). Students typically gravitate towards majors where the majority of students look similar to them, and this also affects the rate of retention from year to year. Students of all races enter STEM majors at about the same rate, but Black and Latino students leave their chosen STEM major at almost twice the rate of White students (Arnim, 2019). This might be due to the lack of academic

resources to help support them complete their major, but it could also be due to discrimination and bias in STEM that pushes minority students away. This departure from STEM seems to happen early on in their undergraduate careers. Over one third, 35%, of these students switch from STEM majors at the end of their first year (Seo et al., 2019). It has been found that this switch also depends on what URM students want to pursue after graduating with their STEM degree. Doctor of Medicine, Doctor of Osteopathic Medicine, Doctor of Dental Surgery, and Doctor of Veterinary Medicine URM students who come to college with intentions of pursuing one of these professional degrees are 11.5% less likely to persist in a STEM field than those who intend to obtain only a Bachelor's degree (Chang et al., 2014). Obviously, these changes happen for a reason, and people are beginning to question why they are occurring.

Even if URM students make it past the first year of their STEM education without changing their major, there are still students that decide to exit later in their journey. It was discovered that 43% of white students who pursued a STEM major ultimately graduated with a degree, but only 29% of Latina/o students and 22% of Black students who intended to major in STEM ultimately graduated with a STEM degree (Riegle-Crumb et al., 2019). STEM is the only field where this disparity is so prominent. In 2015, Black, Hispanic, American Indian, and Alaskan Native students earned only 14% of all United States science and engineering doctoral degrees, even though they comprise nearly one-third of the US population (Kinoshita et al., 2020). These statistics are surprising, and it is important to look into why these differences exist.

This disparity happens in college, but it also continues into the workplace. The proportion of URM students in science and engineering would need to triple to match

their share in the population; this is not due to a lack of interest but rather poor degree completion rates (Chang et al., 2014). In order to understand why minority groups are underemployed and underrepresented, it is important to look at possible reasons why. Reasons cited for why there is a higher number of minority students who switch out of STEM majors include barriers perceived by the students, lack of mentorship, and a lack of a sense of belonging (Fouad and Santana, 2017). The existence of these challenges that they face can be supported by comparing growth versus fixed mindsets. A growth mindset is defined as believing that ability is malleable while a fixed mindset is defined as believing that ability is fixed. It has been found that more White students than Black students have a fixed mindset; the Black students reported a higher amount of growth mindsets, supporting the hypothesis that URM students emphasize the role of effort in achievement (Seo et al., 2019). This idea could possibly play a role in this disparity.

These issues that start during education carry on into the workforce, causing URM to feel like they do not belong or are unwelcome in STEM. Deana Crouser, a Latina student from the University of Washington and a former chemical engineering major, said “I spent too much time in my head feeling like I didn’t belong, or wasn’t smart enough, that I couldn’t focus on my work” (Arnim, 2019). Due to the fact that there are less URM students in STEM majors, racial minorities are underrepresented in jobs, even though there is a shortage of STEM workers. Some believe this is due to social cognitive theory, which says that these students make career decisions based on beliefs about themselves (Seo et al., 2019). Even if a URM student successfully graduates with a STEM degree, there are also issues of fewer job offers, lower salaries, and fewer promotions in their future. There is a persistent gap in receiving no job offers (about 5%)

in the biological sciences between White PhD recipients and Asian, Black, and Hispanic PhD recipients, and Black engineers are even 61% more likely to have no job offers (Kinoshita et al., 2020). These situations and events are just a small part of what can dissuade a URM student from pursuing a STEM degree.

Despite all this, there are still reasons why URM students continue with their STEM major. For some, it starts with math self-confidence and ability, since math is such an important aspect of STEM; having parents in a STEM career or another role model is also a strong predictor of choosing a major in STEM disciplines (Fouad and Santana, 2017). These examples of self-efficacy, outcome expectations, and social support all influence degree decisions. It has also been found that when Black students are enrolled in schools where their racial demographic was the majority, there was a statistically significant probability that they would declare a STEM major; also, partaking in a high school STEM course can serve as a catalyst for potentially choosing a STEM-related college major or career, but just one remedial mathematics course severely constrains a student's opportunity to complete an advanced level mathematics course by the time they graduate (Casto & Williams, 2020). When URM students come to college, there are other factors involved. Minority students are more likely to sustain interest in a STEM major if they come to college for a specific career, work with faculty on research, and had a high grade point average in high school (Fouad and Santana, 2017). When URM students are able to get involved in URE, it can really benefit them, especially if it is a positive lab environment and students enjoy everyday research tasks. It can enhance students' ability to think critically, improve student learning, and influence student persistence in STEM; it can also prove useful for future careers (Cooper et al., 2019). There are many benefits

to participating in URE. It has been found that URM students who participated in programs that exposed them to research were 17.4% more likely to persist in STEM than those who did not (Chang et al., 2014). Even though these are some reasons URM students stay in STEM, they are disproportionately represented in science.

Part of the background research included watching *Picture a Scientist*, a documentary from 2020 that shows leading women scientists discussing the inequalities they have faced and the measures they are taking to make STEM more open to all. For example, at major research universities, 7% of deans and fewer than 3% of provosts are women of color, and fewer than one in twenty-five speakers at chemistry conferences is a woman of color (Shattuck & Cheney, 2020). Raychelle Burks, a professor of analytical chemistry at St. Edward's University in Austin, Texas, is one of the scientists featured in the film. Growing up, she had no Black, female chemistry professors, and in her university's school of natural sciences, Dr. Burks is the only Black tenure-track professor (Shattuck & Cheney, 2020). Dr. Burks shared a few of her experiences as a Black woman in STEM. In one instance, she was sitting at her desk, working on her computer in her office, and someone came in unannounced and assumed she was the janitor (Shattuck & Cheney, 2020). She also described other situations, such as inappropriate emails and meetings where she speaks up and it is like she did not say anything. In another situation, Dr. Burks was parking in the faculty lot, and a person leaned out of their car and asked "Do you work here? Are you faculty? Because this is a faculty lot", despite the fact that she had a faculty sticker on her car (Shattuck & Cheney, 2020). She discusses feelings of isolation, underestimation, and the expectation of being treated poorly, and even though she got used to it, she also felt hyper-visible because she wondered "Why am I here?".

Sangeeta Bhatia, another female STEM professional from the film, has her PhD in biological engineering. At the beginning of her freshman year, half of the class was women. She wondered "What's all the fuss?", as far as the representation of women in STEM. She heard the phrase "It's just a matter of time" from multiple people but did not really think anything of it. By senior year, there were only seven females in a class of one-hundred, and she attributes the leaky pipeline to sexual harassment (Shattuck & Cheney, 2020). This is reported more often than people think. In 2018, the National Academies of Science, Medicine, & Engineering released a report on sexual harassmeent in STEM fields; 50% of women faculty and staff in academia have experienced sexual harassment in the workplace (Shattuck & Cheney, 2020). The film describes the sexual harassment that these women have faced through the analogy of an iceberg. The facets that receive the most attention, such as unwanted sexual attention, coercion, and assault, make up only 10% of cases, while the other 90% includes subtle exclusions, not being invited to collaborate, vulgar name-calling, obscene gestures, hostility, being passed over for promotions, relentless pressure for dates, remarks about bodies, and sabotaging of equipment (Shattuck & Cheney, 2020). These are just a few of the stories and experiences shared by various women throughout the film.

Research Methodology

The research for this work has multiple facets. After deciding on this topic with my advisors in January 2021, meetings were held throughout the whole process to help with development and completion. First, I completed the Collaborative Institutional Training Initiative (CITI) in January 2021. Next, Black professionals in STEM were interviewed via Zoom. One interview had already been completed by another set of

students; then, I completed four more interviews over the course of April 2021 to November 2021. Three interviewees are Butler graduates while the other two graduated from other institutions. Interview questions are given in Appendix A, and interviews were recorded using Zoom. After the interviews, a more in-depth literature search was conducted, looking in particular at the "leaky" pipeline of Black students in STEM and why they leave their majors. This included watching the film, *Picture a Scientist*, to look at the stories of females, particularly those of color, in STEM. Next, the American Chemical Society (ACS) website and the Journal of Chemical Education were consulted for more background research since they have both published work done in hopes of diversifying the STEM field. While carrying out the online research, the recorded interviews and their accompanying transcripts were reviewed to select the appropriate quotes and content to use in the discussion. After planning out how to organize this paper, the writing process began. As progress was made, drafts were sent to my two advisors for feedback. Eventually, a final draft was completed. A poster was also created to display my research, which was presented on April 8, 2022, at the Undergraduate Research Conference at Butler University.

Discussion

The main portion of my research was conducting interviews with Black STEM professionals to hear their personal insight and experiences in the STEM community. Because the interviews each cover the interview questions listed in Appendix A and contain much content, it is not feasible to include each interviewee's responses to each of the questions. Instead, I will highlight some of the responses and accompany them with factual evidence and the experiences of others that I found through my research.

The first scientist interviewed was Percy Bromby in December 2020. Percy attended Knox College in Illinois for his undergraduate degree and went on to DePaul University to receive his Master's degree. He currently works as a technology project leader for Monosol, which is a manufacturer of water-soluble polymer film.

In Percy's twenty-six-minute-long interview, he talked about how he became interested in science, his educational experiences, and advice for schools and other students. He has been interested in science since he was young, specifically experiments and taking things apart to understand how they work. When looking at the start of his undergraduate journey, he touched on the importance of mentors, such as Professor Cropper, and how they helped with the transition to college. Percy was then asked about encountering any challenges as a Black person during his education and training. Although he felt that he did not have many challenges, he did discuss a few unique experiences that stand out in his memory. One was the time he met his first ever Black science teacher, Dr. Mary Crawford, in a college course; Percy said, "I still remember the first day of class seeing her…walk down the stairs to take the podium. Like, oh wow, this is actually a new experience…from the get go, I was very interested in sort of learning more about her progression to where she is because for me, it was something so new and novel." Aside from this, Percy described a mostly positive undergraduate experience. Even when he decided to switch out of the pre-medicine track, he received good support and encouragement to stay in the sciences.

When asked about how his institution and faculty could have done a better job at supporting him, Percy touched on a couple ideas. He said:

> These artificial walls are placed in front of students of different backgrounds for whatever individual bias, which is unfortunate… A lot of times it's just an element of providing support, which would be beneficial… These hurdles are placed in front of them… a lot of the students do have the sort of mental capacity to…complete the project work or perform really well in class, but you know these barriers are placed in front of them…from my personal experience, I really did benefit from a good environment.

He went on to elaborate by talking about the importance of schools having a welcoming and open environment to improve the experiences of all students, and he said that schools need to understand the individual needs of Black scientists to help them succeed.

As for advice for students if they face similar situations, Percy emphasized the significance of being curious and persistent along with finding a mentor that looks like them. He said, "I think a lot of interest is driven by exposure and representation…if you see someone who is similar to you and they're doing that role, it sort of gives you a model, like something you can model your career, your development after…my advice is always to find a mentor as a start". Situations may sometimes need to be treated on a case-by-case basis, but overall, students' needs must be assessed and met in order for them to flourish.

During the background research, sources were found that echoed what Percy said. In an article published by the American Chemical Society (ACS), a C&EN reporter spoke with some Black scientists to help amplify their voices to the chemistry community. Abraham Beyene, a researcher at the Howard Hughes Medical Institute, spoke about his experience as a Black scientist and had similar responses to Percy. After being

encouraged to pursue his PhD as an undergraduate student, he found his place on campus in the Meyerhoff Scholars Program, a program designed to support underrepresented minorities in science, and it became his family and support system on campus. When he went on to graduate school at the University of California, Berkeley, he saw even fewer people who looked like him. “And it just feels very odd being alone, right? And those are really, I think, the most challenging times…if you could work at the undergrad level very, very hard and maintain a very good, steady supply into the graduate school level, then you stand a chance of really tackling this problem”, Beyene said (Remmel, 2020). This mirrors the part of Percy’s conversation where he talked about the lack of scientists that looked like him.

Another work done by the ACS outlined problems with diversity in STEM and was similar to what Percy mentioned. “In addition to the lack of minority faculty, many graduate departments in chemistry do not have a critical mass of minority students. Therefore, graduate student access to minority faculty and peers for support, socialization, and guidance is lacking” (Fadeyi et al., 2020). The authors believe that chemistry departments need to work on recruiting minority students and should have resources dedicated to retention as well. They also think faculty should receive training for mentoring. “Most faculty do not receive formalized mentor training. In cases where they do, it is unlikely that the training also addresses cultural and gender concerns” (Fadeyi et al., 2020). All of this would help maintain a positive racial climate and create a culture that values quality mentorship of students.

This issue has even been recognized at the national level. Representative Eddie Bernice Johnson, Chairwoman of the U.S. House Committee on Science, Space, and

Technology said, “So far, we have gotten by with a STEM workforce that does not come close to representing the diversity of our nation. However, if we continue to leave behind so much of our nation’s brainpower, we cannot succeed” (Burrows et al., 2020). This statement was made specifically in regards to combating bias in all aspects of the publishing process, which includes systemic underrepresentation of Black scientists in this endeavor. In response to this, the organization has committed to the following actions: gathering baseline statistics on diversity within their journals and annually reporting on progress, training editors to recognize and interrupt bias in peer review, including diversity of journal contributors as an explicit measurement of Editor-In-Chief performance, and appointing an ombudsperson to serve as a liaison between editors and the community (Burrows et al., 2020). It is important to combat racism and increase diversity in this format because it helps to expand the views of what a scientist looks like and helps more viewpoints reach the scientific community.

Next, Felicia Fullilove, PhD, was interviewed in April 2021. Fullilove is a 2008 Butler University graduate and attended Emory University from 2008 to 2014 to receive her PhD. After completing a one year postdoc at Emory, she taught organic chemistry at Spelman College for three and a half years. Fullilove worked at the National Science Foundation from 2018 to 2020 before finding her current job at the ACS as a Director for ACS Approval Programs.

The interview with Felicia lasted a total of fifty-four minutes, and she answered all questions extensively and honestly. Felicia has always liked math and science, even from a young age, and she knew she wanted to pursue a chemistry degree in college because her aunt and grandmother worked in science. When she came to Butler

University, she felt that the department did a good job of supporting her, especially Dr. Wilson, Dr. O'Reilly, and Dr. Esteb. She also felt that Butler does a good job of helping create community and described her time participating in the Dawg Days Pre-Welcome Week program. To further elaborate on her experience, she discussed how it felt to be a Black chemistry major: "When I was at Butler, I was one of the only Black chemistry majors, and then I went to graduate school, and I was the only Black person in my program for five and a half years…after a while it becomes a…'why aren't other people that look like me existing in these spaces?'". She also felt that there were some issues with the administration during her education at Butler; she described that there was a string of racially motivated things on campus where people did not feel like they were being heard, and she felt that the administration acted like they did not care. Even though she mentioned feeling supported and a part of the community, she also thought that there was still some segregation and division among students, which led to her Butler experiences depending on what friend group she associated herself with.

When Felicia went on to graduate school at Emory, she described it as a much different experience than the one she had at Butler. She remembered that Butler had a lot of women that were tenure-track faculty or were already tenured, but Emory had very few women faculty and did not tenure a woman in their chemistry department until 2012. This was a difficult experience for her, and she said "I think, me thinking about myself as a woman, as a Black woman, is this a career, is this a community I can really exist in and feel successful in? I think it really caused me when I was in graduate school to have a lot of competing thoughts of 'What do I do?'". Her transition to Emory was difficult, which Felicia thought was partially due to being "coddled" at Butler. Her PhD advisor mainly

wanted her in the program to help with research and did not really serve as a mentor. She realized how male-dominated the field is, and she would hear people use unprofessional adjectives to describe female faculty, such as ‘she’s difficult’ or ‘she’s not that smart’.

In discussions about challenges that she had as a Black person during her education, she had a lot to say on the topic. People would make assumptions about her in graduate school, such as being a first generation college student, even though both of her parents went to college, and it seemed like they wanted to assign every Black undergraduate student in the lab to her because she was the only Black member. She said, “I think it’s the assumption thing. People make a bunch of assumptions about you, or because I was a Black student, they wanted me to mentor every other Black undergrad that came into the lab…like okay, I get it. I don’t mind doing this, but why am I receiving extra work and it’s not equitable…”. Along with the assumptions, she talked about the lack of awareness some people had and some of the generalizations that people made in a racist or sexist regard. Felicia said, “Most of my experiences are good, but it’s just people having a lack of awareness…you really need to be thinking about ‘why am I saying this, like do I have evidence that this is actually real? Do I have data that supports this? Or am I just saying this because it’s my opinion?’”. She thinks that the atmosphere, especially the mental health part, of graduate programs is improving, but it also depends on where a student goes and who their mentor is.

Felicia also talked about some struggles she had in the workplace. When she decided she no longer wanted to be a faculty member at Spelman College, she was told by another academic coworker, “You can’t leave the academy because you’re a Black woman and there’s not enough so you need to stay”. She was taken aback by this

comment. She felt that, “I should have choice about what I want to do with my life, and it shouldn’t be that because there’s so few, I can’t leave, and I can’t utilize that choice”. Felicia thinks that this conversation is representative of a larger problem in her field. “I think the issue is not me leaving. It is ‘why aren’t there more people like me here?’. And so I do think those are conversations that happen and that are awkward”, and she believes that “It’s not my responsibility to be the representation for my entire race or for my entire gender”. When looking back at these challenges, she did have some advice to pass along. Felicia thinks that there is power in numbers. Building a community, which should include allies, advocates, and fellow college alumni, is what she has found to be the best way of making it through the experiences she has had.

It was interesting to hear about Felicia’s position at the ACS and then read about the work they and other organizations are doing to increase diversity in STEM. The director of the U.S. National Institutes of Health, Francis Collins, said “NIH is committed to instituting new ways to support diversity, equity, and inclusion, and identifying and dismantling any policies and practices that may harm our workforce and our science”; they recently created UNITE, which aims to make biomedical research more equitable and remove barriers that hinder diversity in the biomedical workforce (Widener, 2021). The ACS is also working to confront racism in chemistry publishing. Sarah Tegen, senior vice president of ACS publications, said, “The underrepresentation of Black scientists in chemistry shows us how overdue we are for change” (Wang, 2020). “By challenging our own beliefs and actions, and through the changes we are making at ACS Publications, we will strive to build a better scientific community, and ultimately a better world”, said James Milne, president of ACS Publications (Wang, 2020). Increasing representation in

STEM through publications, research, or by reforming curriculums to equally represent contributions will help to broaden the image of a chemist in the classroom.

Amongst the background research, there were others who shared similar stories and sentiments to Felicia. Cicely Shillingford, a fifth year chemistry PhD student at New York University, was the only Black student in the department until last year. She said, "Institutional silence sends a message that is loud and clear: some faculty are more concerned with political correctness than they are about assuaging the pain imposed upon their Black students and colleagues. Silence speaks deafeningly to the effect that optics are valued above denouncing the malignant White entitlement that is laying Black communities to waste" (Wang & Satyanarayana, 2020). This problem is not only seen from a student's perspective but also from a faculty member's side, both of which Felicia described. Sibrina Collins was another scientist the ACS spoke with; she said, "As a former assistant professor of chemistry, I would frequently incorporate biographical narratives into the chemistry curriculum to broaden the image of chemistry in the classroom. Most chemistry textbooks do not include images of chemists of color" (Wang & Satyanarayana, 2020). All of this mirrors what Felicia discussed in her interview about the lack of diversity in STEM.

This underrepresentation is not a new issue. The Science and Engineering Equal Opportunities Act (SEEOA) was signed into law forty years ago by President Jimmy Carter with two goals in mind. The legislation appointed the National Science Foundation (NSF) with "the task of safeguarding the involvement of underrepresented groups in American STEM fields", and it "enabled the NSF to play offense against bias" (Fadeyi et al., 2020). Even with this law, representation in STEM is not much better than it was

forty years ago. The late Professor Gilbert Stork stated, “One could argue that chemistry is no more accessible for a Black chemist in 2013 than it was in 1916 when St. Elmo Brady earned his PhD” (Fadeyi et al., 2020). This is why the work must continue to make STEM diversified and widely available for all.

Dominique Stephens, PhD, was interviewed next in May 2021. He is a 2014 Butler University graduate, and he currently is a postdoctoral fellow at the University of Texas-Austin in the virology lab where he looks at the innate immune response and how the inflammatory response can be controlled. In between his undergraduate studies and his PhD, he attended both Georgia State University and Howard University to obtain his Master’s degree. Ultimately, he hopes to work in academia and have his own lab.

Dominique’s interview lasted a little over fifty-one minutes. Growing up, he was always interested in science; he watched lots of science shows and had his sights set on becoming a paleontologist. In his hometown, there were not many opportunities for science-related activities, such as science fairs, but his parents encouraged him to do whatever he wanted to do, which was science. When he came to Butler, he felt supported in so many ways as an aspiring scientist. One professor in particular, Dr. Johnson, played an important role in Dominique’s scientific development. He got a recommendation from another student who was a senior at the time to ask Dr. Johnson about doing research, and he agreed to let him work with him. In their conversation, Dr. Johnson said something that still sticks with him today and makes him want to be a mentor to others: “He said, ‘Anything I don’t know he’ll teach me, and anything we both don’t know we’ll learn together’. I don’t know if he knew how powerful those words were at the time, but those things stuck with me”. After he started doing research, the whole department rallied

around him, particularly Dr. O'Reilly and Dr. Hoops, and he described it as a great community.

When asked if there was anything else the department could have done to support him, Dominique only mentioned positive things and even said that he was able to stick out his PhD because of his initial good experience at Butler. He said, "I don't know if they could've done anything better than they did. They did more than enough, more than what anyone else would've done anywhere else. I've seen that, being everywhere that I've been, they did above and beyond what most departments would have done". Getting into graduate school and PhD programs was tough for him because he did not have the best grades, and the department was very supportive during the whole process.

When asked about unique challenges during his education, Dominique talked about being behind when he came to Butler. He said, "Being in an underserved community kind of hindered my education once I got to Butler because I was behind…professors said 'Oh yeah, you should've learned this in high school', and I'm like 'I don't know what this is. In high school? What class is this?'. Things I guess I should've learned in high school I didn't…it was a real challenge to catch up". He knew college would be hard because Butler is prestigious, but this was an extra hurdle he had to overcome. He was thankful for the support system and study groups he formed because they encouraged him to keep going. He also described most of his peers at Butler as welcoming, but coming to campus was a culture shock for him. He grew up in an all-Black community in Fort Wayne, and during his experience as a resident assistant, he met people who told him they had never met a Black person before.

When comparing his graduate experiences to Butler, they were much different. The whole atmosphere was different; it was less inviting, and the faculty was not looking out for his best interests. Dominique was the only Black person in one of his programs, which led to him being looked at and treated differently. He felt that he was treated as a worker and not a scientist or mentee. He even had someone tell him that with his attitude he was not going to get anywhere and would not find a job. As for advice for other students who face similar situations, he said:

> Science is still a part of the larger community so there's going to be discrimination; there will be racism. I experienced it. I actually was a PhD student at Georgia State before leaving because someone called me a racial slur and because I spoke up about it I had to leave. I left with my Master's degree. Still, I had to leave after putting in all of this work. Don't get discouraged, especially if you run into anything like that. Don't get discouraged. Don't be like 'Well, I'm going to quit this' because if it's something you truly love then there's no reason to quit it.

He also felt that universities could improve the experience for Black STEM students by reaching out to them and making them aware of the opportunities that are available, such as research.

While doing the background research, it was discovered that others had similar experiences to Dominique. Steven Townsend is an assistant professor in the Department of Chemistry at Vanderbilt University. Growing up, he always liked science; he was a kid who loved to experiment and remembers not finding any books on scientists who were not White men. Fortunately, he had a supportive undergraduate mentor that helped him

throughout his education (Remmel, 2020). Townsend also had eye-opening experiences during his education and career. He said, “At a recent conference, a senior faculty member in chemistry joked that he remembered my application for graduate school 15 years earlier…the admission committee “did their homework” and didn’t admit me to their program because “you grew up too poor””; the committee “felt my family would hinder any success I could achieve in any professional field” (Fadeyi et al., 2020). Townsend believes the first problem is that URM students are asked to dismantle an institution they did not build, with the solution being that we need to diversify the field. Second, students who are from a financially insecure background are at a disadvantage since graduate students are treated as employees rather than students. Also, most departments do not have faculty members who are people of color, which makes it difficult to make connections with others of color.

Reporter Ariana Remmel interviewed Black chemists on the podcast *Stereo Chemistry* in September 2020, and the podcast had a variety of perspectives on this issue. Institutions must ensure students have “a sense of community, financial support, and strong career guidance at the undergraduate level” to help in addressing some of the key barriers Black scientists face (Remmel, 2020). The importance of mentors was also discussed. Mentors do not need to be the same gender or ethnicity as their mentees to be supportive, but they must educate themselves on the challenges their mentees face. Effective allyship is necessary; people with privilege must step up to share the burden of dismantling a broken system that discriminates against Black chemists. “Black scientists have had to become educated on diversity, equity, and inclusion so that they can advocate for themselves”, which means that those with privilege must also do their part (Remmel,

2020). In order to combat this issue, we must work to educate ourselves, listen to Black colleagues, and apologize when mistakes are made.

Next, Dorene Hinton, MD, was interviewed in June 2021. Hinton is a 2014 graduate of Butler University where she received her chemistry degree. After Butler, she completed a post-baccalaureate program, MEDPREP (Medical/Dental Education Preparatory Program), at Southern Illinois University School of Medicine. She went on to attend Southern Illinois University School of Medicine, and she is currently at the Medical College of Wisconsin for her residency in anesthesiology. Ultimately, she wants to move south and work in academics because she enjoys teaching; she would also like to open a nutrition business due to her passion for health and nutrition.

Dorene's interview was a total of forty-one minutes. She found her interest in science at a young age. She was good at math growin up, which led to her interest in solving scientific questions and projects. While she was in high school, her brother pursued a microbiology degree, and this showed her that a science degree, specifically chemistry, was an attainable goal. Coming to Butler, Dorene was nervous about moving to campus and meeting people, and participating in the Pre-Welcome Week program, Dawg Days, helped her make the transition. She said general chemistry was a challenge at first, but she went to office hours. Her major was a little challenging, but she still enjoyed it. She mentioned one professor in particular, Dr. Morgan, who was a good organic chemistry resource and helped her develop her analytical thinking. In her opinion, professors were open and available for chemistry help, although she did think that the help for those on the pre-medicine track was lacking.

As far as challenges she experienced as an aspiring Black scientist, there were a few occurrences she could recall. Dorene said she excelled in high school, but they did not offer many advanced courses. This made her coursework at Butler challenging at first, but it was a hurdle she got over quickly. She also felt that she did not know who to ask for help besides professors and never really formed any study groups. She also had experiences at Butler where some professors indirectly made comments about her background that made her question her experiences. Dorene said:

> At Butler, some challenges with, not in chemistry but just in general throughout the entire four years, some professors indirectly might say things and not think that it means anything or will have an effect on you but it did…it made me question…'What was that even about?'…just statements about my background, but not just between me and the professor, like in front of the entire class, which isn't necessary. If you want to know, we can have this conversation, but the conversation didn't have anything to do with anything at the time.

She never felt discouraged at Butler from pursuing science, but she does feel that people need to be more culturally aware. This leads into her advice for current students of color and institutions. She believes that students should not be afraid to ask for help or branch out to new things, but institutions need to understand that people come from different places with different backgrounds, which also means that advisors must be prepared to help these students and provide extra assistance when needed.

It was found that others had similar experiences and feelings to what Dorene discussed. Marie Heffern, an assistant professor at University of California, Davis, spoke

to the ACS about diversity in science and touched on implicit bias affecting the development of science identity. She said:

> As an undergraduate student, I had a spotlight article written about me with the intention of celebrating my research achievements. The article started with, "former high school cheerleader interested in studying theater, Marie Anne Cuevas may seem an unlikely student to excel in nanoscience"…This caused me to wonder what it would take to be a student "likely" to excel in science. It also caused me to fear that I would never be taken seriously. (Fadeyi et al., 2020)

It is important to not only recognize that implicit bias exists, but it is also important to understand that it can directly challenge the development of a trainee's science identity. That is why it is crucial that support of Black scientists' development is enhanced.

Various literature sources also concurred with what Dorene said about a student's background playing a part in their education. "Not every scientist comes from similar backgrounds with identical access to resources"; "racial and socioeconomic disparities are not the fault of the aspiring scientist, but a reflection of centuries of inequalities that have manifested in the form of slavery, prison sentencing, neighborhood and school access-in addition to others" (Fadeyi et al., 2020). Real change must be made to fix these barriers that Black scientists face. This includes re-establishing industry-funded science programs for minority students, instituting industry-academic leadership training programs, changing the hiring process to be less prescriptive, and developing formal mentoring programs (Fadeyi et al., 2020). Minority representation must be increased in the STEM field, and the conversation needs to keep happening to raise awareness and provide solutions. Zakiya Wilson-Kennedy, assistant dean for diversity and inclusion and

associate professor of research and chemistry education at Louisiana State University, had this to say on the issue: “For colleagues who want to support their Black colleagues and students, I would encourage them to interrogate or question what is happening around you. Be willing to be in uncomfortable spaces”…“Be courageous in acknowledging the realities of systemic and institutional racism and our personal and conscious biases” (Wang & Satyanarayana, 2020). Allies play an important role in fighting against these problems in the STEM field, and they are vital for making change worldwide.

Finally, Tamiko Porter, PhD, was interviewed in November 2021. She attended Michigan State University where she received her undergraduate degree in biochemistry in 1997; she received her PhD from Texas A&M University in 2004. She is currently a lecturer and academic advisor in the Department of Chemistry and Chemical Biology at Indiana University-Purdue University Indianapolis. She also runs the Louis Stokes Alliances for Minority Participation (LSAMP) program, which supports underrepresented minority students in STEM and tries to increase the number of those who graduate with STEM degrees. She hopes to achieve teaching professor and to continue mentoring students.

The interview with Tamiko lasted almost thirty-three minutes. Growing up in Detroit, she was always interested in science, and her parents encouraged her to read and do what she loved. She found an interest in logic puzzles and games, so she gravitated towards math at first. When she went to college, she switched to biochemistry and began working in a research lab. After taking a gap year and working in another research lab, she was urged to pursue her doctorate. Tamiko thought the people, opportunities, and

campus during her undergraduate career were all great; advising made a big difference, and tutoring helped her find peers.

Although she had good things to say about Michigan State, she also felt there were things that could have been done better. Tamiko said:

> I would say on the race issue, it's not something that was addressed…as a science major, math major, and I can say in my position now, it's not something we always address or support students with…I do remember getting some remarks from peers my first year that had me crying, right, because there were insensitive and kind of rude comments…I remember crying to my RA…I had to just kind of deal. I don't remember any resources or support or people I could go to who really helped or gave me resolution. I just had to suck it up and ignore it.

She also mentioned that the environment her first year was not good, but she could not think of any specific person that discouraged her from science. "I know what I feel, or have felt, are what I have alluded to and are what we call microaggressions, so I think that that's sometimes been tough, so it's the little things that people say or don't say that impact things", she said. Tamiko also discussed times, both as a student and faculty member, where she noticed that leaders think they know what students need. They seem to make generalizations about groups of students and their needs, which is bad, because the needs of every student are different. In her advice for current students of color, she believes finding an ally to help with having those difficult conversations is essential.

In hearing what Tamiko had to say about her experiences as a student and faculty member and what changes she believes need to be made, it was interesting to read about changes some universities are making to courses. One example was in a general

chemistry course at Barnard College in the fall of 2020. It was a relatively low stakes course (only one credit, pass/fail grading mode), and it created a space for intense conversation, reflection, increased understanding of racism in chemistry, and impetus for institutional change. Late in the summer of 2020, seven students and alumni sent the chemistry department a letter asking them to consider making changes to dismantle racist practices within the department; the letter also pointed out how tired Black people are of explaining over and over the premises of racism in America and how it is time for White people to do part of the work of educating others about systemic racism (Babb & Austin, 2022). When looking at student reflections during the course and at the end, responses were thoughtful and showed that students were engaging seriously in the material. Many students were taken aback by how stark the gap between women/people of color and White men was, showing that women and underrepresented races are tolerated but not always welcome in science (Babb & Austin, 2022). They also touched on the "weed out" mindset, meaning to get rid of those who are deemed less capable, sometimes employed in STEM because this creates even more exclusion in the field. The main takeaway from the course was that there needs to be regular opportunities for students in STEM to talk about racism, indicating that institutions need to truly prioritize inclusion and diversity.

Another example listed by the *Journal of Chemical Education* was in a biochemistry course in the fall of 2020 at a private, historically White liberal arts undergraduate institution. A theme of "Racism is a Public Health Emergency" was incorporated as an overlay for an existing biochemistry curriculum at the university; the overlay gave students time to participate in regular activities that directly integrated discussions of racism, social justice, and equity with the biochemistry topics covering

during that week, meaning they spent class time learning both biochemistry content and discussing these issues (Hollond et al., 2022). At the end of the course, the results showed that the incorporation of this overlay was beneficial to students. They indicated that the overlay's inclusion did not negatively impact the coverage of biochemistry content. Instead, it increased the relevance of the course material, and students reported a high level of understanding of the impact of bias and race in the field of biochemistry. There was a strong agreement, 81%, with the statement: "The inclusion of the theme, Racism is a Public Health Emergency, into the course made the material more relevant to me", and specifically, nine out of twenty-six (34.6%) students cited the overlay as one of their five most important things they learned in the course (Hollond et al., 2022). Looking at all of the results, the overlay did not result in any decrease of learning scientific content and increased the relevance of biochemistry in their everyday lives. When asked about including these themes into other chemistry classes, most responses, 90.5%, were positive, and many gave suggestions for placement into other courses (Hollond et al., 2022). Overall, the results of this overlay further demonstrates the need to integrate discussions of racism, social justice, and equity into STEM classes.

In looking over all that is included in the discussion, similarities were found. First, most Black scientists were interested in science and math at a young age but needed help maintaining that interest. For example, Felicia wanted to pursue chemistry because her mother and grandmother were in science, and Dominique watched science shows and wanted to be a paleontologist growing up. Tamiko loved logic puzzles and games, and with her mother's encouragement, she gravitated towards math. Steven Townsend, who was interviewed by the ACS, always liked science and loved to experiment as a kid.

Despite this interest, all touched on challenges they had as Black STEM majors, which also meant that they needed something to maintain their interest.

Multiple Black scientists discussed the topic of others making assumptions based on race or due to implicit bias. Felicia mentioned that someone assumed she was a first-generation college student, even though both of her parents attended college, and Dorene said that professors made statements about her background in front of other students, which led to her questioning the professors and what they meant by it. Heffern talked about implicit bias and used the article that was written about her, which mentioned that she seemed unlikely to excel in nanoscience and led to her own line of questioning, and Townsend discussed that a professor told him he "grew up too poor" and ultimately did not get accepted to graduate school.

To help with these challenges, most mentioned the importance of a mentor. Finding a mentor can help any student, especially if they are similar to the student in some way, such as race or gender. Percy had his first Black professor, Dr. Mary Crawford, at Knox College, and was immediately interested in her career path because she was his first teacher that looked like him. Dominique mentioned Dr. Johnson and his great experience working in his lab; his mentorship led to Dominique wanting to pursue his PhD and made him want to be a mentor to others.

This goes along with broadening the image of what a scientist looks like. Diversity must be increased in STEM in order to do this, not just in the classroom but also in all STEM jobs and publications. This additionally helps students find mentors or other people successful in their field of choice that are similar to them, and it shows them that success is possible regardless of background. Another side of increasing diversity in

STEM is gaining more viewpoints. When we have people from different backgrounds, we receive ideas from those with different viewpoints, which makes our STEM field more successful because we have a wider array of ideas.

Possibly the most important topic discussed was that people need to be educated on these issues in order to be an ally, relate to others, and dismantle the system. People of all backgrounds need to be able to take action, not just their Black colleagues. This helps to maintain a positive racial climate and a space that is open for those difficult conversations surrounding race in STEM. Being educated also helps others understand that disparities and implicit bias do exist and play a role in the lives of Black scientists. It helps mentors and employers be more effective at their jobs, and it ultimately shows that one stands in solidarity with them.

As it was discussed, work is being done to combat racism in STEM; for example, the two courses described earlier. The NIH made UNITE (which aims to remove barriers that hinder diversity in the biomedical workforce), and the ACS is working to diversify their publishing. It is even being recognized at the national level, seeing as Representative Johnson, Chairwoman of the US House Committee on Science, Space, and Technology, has spoken on the issue. Even with this progress, this work must continue to make the STEM field equally diverse. As it can be seen from those interviewed and the online sources consulted, the work is far from over.

Conclusion

This project looked at the STEM education experiences of Black professionals from both the Butler community and outside of it. There were five individuals interviewed (three Butler graduates and two non-Butler graduates), and their experiences

were compared to other Black STEM professionals across the nation. It was found that what was discussed during the interviews paralleled what was discovered in the research. Many are interested in science at a young age but need help maintaining interest. In order to combat the problems that they face, such as assumptions made based on race, finding a mentor is helpful. It is also crucial that the image of what a scientist looks like is further diversified and that the STEM community is educated on this topic in order to be allies and take part in the fight. Most importantly, there is some work being done by various organizations to combat the systemic racism we see in the STEM field, but we must continue this work in order to dismantle it.

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Appendix A: Interview Questions

1. What is your current job? Could you explain what that job entails?
2. What are your career goals?
3. Growing up, how did you become interested in science? Follow up: Were there any individuals or experiences that had a particularly strong, positive impact on you?
4. In what ways did your undergraduate institution support you as an aspiring scientist? Follow up: How could the institution or faculty have done a better job at supporting you? Follow up: What could your peers have done to better support you?
5. Did you encounter any unique challenges as a Black person during your education and training? If so, do you feel comfortable sharing a little bit about those challenges? Follow up: Do you have any advice for current students of color if they face a similar situation?
6. Did anyone actively discourage you from pursuing science? Did you encounter more subtle discouragement? If so, do you feel comfortable sharing about that experience(s)?
7. What suggestions do you have for institutions to improve the experiences of aspiring Black scientists?