Origins of early STEM interest for Black male graduate students in engineering:
A community cultural wealth perspective

Abstract

The development of talent in science, technology, engineering, and mathematics (STEM) fields remains a national priority, one for which increasing the number of STEM participants from historically underrepresented populations is germane. Increasing the number of historically underrepresented students who complete advanced degrees in STEM will not only aid in solving national problems such as building infrastructure and strengthening national security, but also provide more models of success for future generations. Addressing this priority requires developing a better understanding of what leads students into and through STEM pathways, and finding ways to eliminate systemic barriers to their participation in STEM. This study reports on the origins of early STEM interest among 30 Black male graduate students in engineering. Using a community cultural wealth perspective, this article uncovers the people and activities that nurtured students into and through STEM pathways. The findings from this study provide clues to the social support and activities necessary for early interest in STEM.

Keywords: Black males, origins, broadening participation, community cultural wealth

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Biographical Sketches

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Developing talent in science, technology, engineering, and mathematics (STEM) remains a national priority, one for which increasing the number of STEM participants from historically underrepresented populations is germane. For instance, in the United States in 2015, only 2.5% percent of the engineering professoriate, 3.2% of engineering doctorate recipients, and 1.6% of those enrolled in engineering doctoral degree programs were Black (Yoder, 2015). Increasing the number of historically underrepresented students who complete advanced degrees in STEM will not only aid in solving national problems such as building infrastructure and strengthening national security, but also provide more models of success for future generations.

Scholarship suggests that early interest in math and science is a key factor in nurturing participation through STEM pathways (Maltese, Melki, & Wiebke, 2014; Williams, Burt, & Hilton, 2016;). Maltese and Tai’s (2009) study on the origins of science participation reported that 85 out of 116 graduate students referenced an early interest in science; specifically, 65% of participants reported that their interest began prior to middle school, 30% in the middle or high school years, and only 5% beginning with their college matriculation (Maltese & Tai, 2009). This indicates that most STEM students develop their interest during formative educational years.

Even students who become interested at early ages, however, may face obstacles that threaten participation in STEM (e.g., underresourced schools, culturally irrelevant pedagogies, teachers who do not see their potential) (Berry, 2008; Hrabowski & Pearson, 1993; Moore, Madison-Colmore, & Smith, 2003; Russell & Atwater, 2005). These barriers prevent kids from gaining valuable preparation for STEM majors and deter them from choosing and navigating problematic weed-out courses and completing STEM bachelor’s and graduate degrees (Brazziel & Brazziel, 1997; Burt, McKen, Burkhart, Hormell, & Knight, in press, Fries-Britt, 2017; Fries-
Britt, Burt, & Franklin, 2012; Green & Glasson, 2009; Williams, Burt, & Hilton, 2016). While a small but growing corpus on the experiences of students of color provides insight into overcoming systemic barriers in STEM (Burt, Knight, & Roberson, 2017; Burt et al., in press; Burt, Williams, & Smith, in press; McGee & Martin, 2011), more work is needed to understand the resources (i.e., individuals and activities) students access during formative years. This article examines the origins of early STEM interest for Black males in engineering graduate programs, asking which individuals and activities nurture their early interest in STEM and how. Gaining a better understanding of the origins of early STEM interest may provide clues to improving policies and practices that broaden STEM participation.

**Literature**

A child’s academic trajectory depends greatly on parental involvement. For example, Strayhorn’s (2010) study of math achievement of Black high school students showed that those with involved parents (e.g., parents attending parent-teacher conferences and PTA meetings) had better records of mathematics achievement. According to Strayhorn, greater school involvement built the social and cultural capital parents needed to help their children navigate the educational process. Similarly, Van Voorhis (2003) found that children turned in more accurate assignments and received higher grades in science when family members helped with homework. Research also shows that parents promote their children’s academic success when they advocate for them. Berry’s (2008) study on eight African American middle school boys’ success in mathematics showed that four of the eight boys were placed into gifted courses as a result of their parents advocating for them despite their teachers’ disregard of their mathematical abilities. Berry’s study also highlighted the role of the broader family – not solely parents – with six of the eight boys noting that their grandmothers consistently rewarded them for their academic performance.
Existing literature has not exhaustively explored “parental involvement.” There are likely to be many other ways in which parents contribute to their child’s achievement. Key to the studies above, however, are the ways in which parents recognized and questioned the systems and structures of oppression that tend to overlook students’ academic potential.

While parents and families share an important role in cultivating and maintaining the STEM interest of Black boys, teachers and school staff have an equally important role in acknowledging, affirming, and ensuring their academic success. Moore’s (2006) qualitative analysis stressed the importance of teachers and school administrators (i.e., school counselors) to African American males’ career trajectories in engineering. For instance, one student recalled that his interest in math was encouraged by a fifth-grade teacher who expressed confidence in his ability and provided additional advanced curriculum worksheets for him to complete. This increased his confidence and motivation and made him realize how much math interested him, and he began to focus on enhancing his math skills. McGee and Pearman’s (2014) study of 13 Black boys with high mathematics aptitudes provided an anti-deficit depiction of Black boys achieving in math despite external challenges. Nine of the boys in the study considered themselves proficient in math from an early age. The authors found that students identified at an early age as mathematically gifted enjoyed and saw themselves as able to successfully do math. Their findings highlight the role teachers play in identifying potential instead of limitations. Specifically, students whose math proficiency was not recognized prior to fifth grade reported that their middle school teachers went above and beyond to affirm their talent. These findings suggest that Black boys whose teachers affirm that they are gifted in mathematics excel and develop a genuine interest. When teachers and school administrators are invested in Black boys’ academic achievement and promote their STEM interests, boys are more likely to continue in
STEM (Brown and Kelly, 2007; McGee and Pearman; Moore, 2006).

The role of “play” in the learning process of children has been well documented (Brewer, 2007; Crowley, Barron, Knutson, & Martin, 2015). Play serves as a catalyst for curiosity, initiative, investigation, innovation, and creativity (Alexander, Johnson, & Kelley, 2012). Further, play (e.g., puzzles, blocks, flashcards, video and internet games) facilitates knowledge development and interest in math and science (Maltese, Melki, & Wiebke, 2014; McGee & Pearman, 2014; Strayhorn, 2015). For play to be an effective tool for learning, however, it needs to be incentivized, encouraged, and intentional. For example, Maltese, Melki, and Wiebke (2014) found that students became interested in science and math through a variety of play activities: building/tinkering, engaging in outdoor activities, and using media (books, television, and video games). They also reported that students’ interest in math and science was cultivated prior to kindergarten. Similarly, Berry (2008) reported that one participant’s love for math was facilitated through play with his father (math games, puzzles, and mathematics problem sets). Play in the form of athletics can also contribute. Brown and Kelly (2007) illustrated how both epistemological and ontological change occurred among high school students on a baseball team as they learned more about the science behind the sport. The baseball coach (who was also a science teacher in the school and the primary researcher for the study) helped his team members see the connections between baseball and physics. The coach mediated students’ learning by helping them understand the physics behind throwing curveballs and implementing drills that required them to practice throwing curveballs. Brown and Kelly found that linking the act of throwing curve balls with the explanation of the science behind the ball’s curving increased students’ appreciation of “being a baseball player”; that is, their understanding of what it meant to be a baseball player deepened as a result of being able to explain the science behind their
sport. When play also incorporates discussion related to education, children may develop conceptual interests in science (Alexander, Johnson, & Kelley, 2012).

Acquiring foundational knowledge in science and mathematics is critical to postsecondary involvement (Berry, 2008; Williams, Burt, & Hilton, 2016; Wright et al., 2016). Acquiring foundational knowledge, however, is connected to understanding the relevance of the material (Hulleman & Harackiewicz, 2009). In a study on the math achievement of eighth graders transitioning to high school, students who expressed early college aspirations tended to stress the importance of math (Williams, Burt, & Hilton, 2016). Enjoyment of math and an emphasis on math achievement were related to early college aspirations and interest in STEM, especially for girls. In a study on high school science activities, Hulleman and Harackiewicz (2009) revealed that students had greater interest in science, and earned higher grades, when class activities were relevant to their lives (Hulleman & Harackiewicz, 2009). A 2012 National Committee of Educational Statistics (NCES) report shows low percentages of African Americans completing high school physics (30.7%), and various biology, chemistry, and physics courses (25.4%). This is problematic because early exposure and access to science courses matter for postsecondary STEM participation. Without opportunities to take higher-level science courses, likely due to a lack of school resources and personnel, students may be unable to take foundational science courses until college (Brown et al., 2017; Wright et al., 2016).

While the influences presented above (i.e., parental and familial involvement, teacher engagement, play-based learning, positive orientation to math and science) are presented separately for the purpose of clarity, in practice, they operate together, often simultaneously.

**Theoretical Framing**
The quantity of research on the perceived deficits of students of color and their broader cultural communities prompted the development of Yosso’s (2005) theory of cultural wealth. Yosso’s theory critiques previous conceptualizations of social and cultural capital based on White, middle-class ideologies and advances considerations of additional forms of capital found in communities of color that promote success (George Mwangi, 2015; Harper, 2010; Rendón, Nora, & Kanagala, 2014). Additional forms most germane to the present study include:

1. Aspirational Capital: Sustaining positive outlooks on the future despite real and perceived barriers.
2. Familial Capital: Utilizing forms of knowledge that are shared and passed intergenerationally, and that offer connections to one’s community, culture, and history.
3. Social Capital: Drawing on networks of people and resources found within one’s community.
5. Resistant Capital: Promoting knowledge and skills through behaviors that challenge inequality.

Community cultural wealth (Yosso, 2005) is a valuable tool to illuminate ways that students of color succeed in STEM pathways (Peralta, Caspary, & Boothe, 2013; Samuelson & Litzler, 2016). In this study on Black males in engineering graduate programs, the theory provides a lens through which to better understand the extensive strengths that students possess, versus solely identifying skills they lack. As a preview from the present study, when Jackson, a third-year doctoral candidate in mechanical engineering, mentions the myriad ways his parents influenced his early interests in STEM, several forms of capital can be seen. First, familial capital might be seen in the ways his parents explained the importance of gaining an education and pursuing STEM, likely related to their own experiences attending and completing college. Further, the encouragement they provided him might be viewed as a form of aspirational capital,
whereby their encouragement overshadowed existing barriers in STEM. It is important to note that Yosso’s forms of capital do not necessarily work in isolation, but overlap.

Using community cultural wealth (Yosso, 2005) as a theoretical framework, this article addresses the following research questions: What were the origins of STEM and engineering interest for Black males in graduate programs? Which individuals and resources nurtured Black male students’ early interests in STEM? How did they do so?

Methods

Data Collection Procedures
This qualitative study draws on interviews with 30 Black males in engineering graduate programs (master’s and doctoral) between 2010 and 2017. Participants, among the most talented and promising, attended one of three leading research universities that belong to the Association of American Universities (AAU) and are ranked in the top 60 (US News and World Reports). At all three institutions, the Black graduate student population was less than 5%. Participants represented the critical mass of Black males in their respective engineering graduate programs.

Students’ engineering specializations varied (fields included electrical, mechanical, civil, industrial, aerospace, chemical, agricultural, materials science, and design engineering) as did their year in graduate school (ranging at the time of data collection from the first year through the fifth). In this article we use the term “Black” to denote the more global diaspora of race. That is, “African American” and “Black” are not synonymous; ten participants considered themselves “Black” but not “African American” (e.g., Nigerian, West African, Caribbean, Ethiopian, and Ghanaian). While seven participants described themselves as low-income, the majority reported growing up in middle-income households. Six said they were raised primarily by their mothers, but most reported coming from two-parent homes. Of the 30 participants, 21 had mothers with
postsecondary education, and four of those had doctorates. Similarly, 18 had fathers with postsecondary education, three of whom had doctorates. See profiles of study participants in Table 1.

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- * Denotes that a student has graduated since data collection
- Class Level: Refers to the number of years a student has been in graduate school
- HS GPA: High School Grade Point Average
- HS Demo: High School Racial Demographic
- SES: Family’s Socioeconomic Status (“L-M” socioeconomic status indicates that a participant marked in between “low” and “middle” on the demographic form)
- House: Household Composition (“Single” denotes that a participant did not specify a parent or guardian)
- Mother Educ: Mother’s highest level of education
- Father Educ: Father’s highest level of education

Institutional insiders (i.e., administrators, peers, and students who had already participated in interviews) helped identify potential participants. Interviews were one-on-one and
semi-structured (Merriam & Tisdell, 2016), and conducted by the principal investigator (the first author). A protocol guided interviews but there was flexibility to ask follow-up questions where necessary. Examples of interview questions included: When do you remember having your first interest in STEM? When you first started to show interest in science and math, did people encourage it (who and how)? You’re defying the odds, how are you doing it? Interviews ranged from one to more than two hours and were audio recorded and transcribed verbatim to capture participants’ vernacular. Participants also completed an eight-item demographic form.

Data Analysis

Thematic analysis was used to identify patterns within the interview data (Braun and Clarke, 2006; Fereday and Muir-Cochrane, 2006). The principal investigator (PI) began by identifying small chunks of text (i.e., codes) that explained the experiences of Black males in engineering graduate programs. This initial coding process revealed that participants’ stories related to how they became interested in STEM and how their early STEM interests motivated persistence in graduate school. The second author then reread all transcripts, focusing on data related to origins of participants’ interest in STEM. After the second round of analysis, both researchers discussed the data specific to origins of STEM interest to identify patterns across participants. During these iterative deliberations, they aimed to better understand the following prompts: when did Black males become interested in STEM, who encouraged their interests, and how were their STEM interests nurtured. Patterned responses to the previously stated prompts coalesced to form themes. To be certain, constant discussions of how chunks of data (i.e., codes) and patterns across participants formed themes ensued until consensus was reached, resulting in the following themes: family members help cultivate and maintain early STEM interest; teachers affirm and strengthen it; early interest in math and/or science creates lasting pathways; and, play connects learning and early interest in STEM. Because of our inductive research approach
(Merriam & Tisdell, 2016), Yosso’s theory of community cultural wealth was not used to guide our analyses. Instead, after the data were collected and analyzed, we drew upon the theory to articulate our interpretation of participants’ experiences.

**Ensuring Quality**

Ensuring quality included several steps (Merriam & Tisdell, 2016). First, the interview protocol was designed to build rapport with participants by starting with broader questions before asking deeper and more abstract ones. This allowed participants to more candidly and freely share their experiences. Second, because the study included multiple institutions, a semi-structured interview protocol ensured consistency across participants. Third, all transcripts were checked against the audio recordings to verify accuracy. This ensured that what participants said was accurately captured in the text data. Finally, having multiple researchers engaged in iterative analysis afforded checks and balances regarding interpretations of data, categories, and themes.

The researchers were also iteratively reflexive about how their identities and potential biases might affect their interpretations of data (Cooper, Jackson, Azmita, & Lopez, 1998; Green, Creswell, Shope, & Clark, 2007; Milner, 2007). For example, both researchers are Black (African American) males in the social sciences (not engineering). They discussed instances when interpretations were influenced by their interests in their field of study and how those might be different from those in STEM fields. They also discussed their own sources of encouragement and nurturing through educational pathways and how they aligned with or varied from those of the participants. While the researchers tried to control for biases and assumptions through their discussions (Peshkin, 1988), they also believe that sharing some identities with participants (e.g., race and gender) allowed for nuanced interpretations of findings that might have been lost on researchers with other identities (Bernal, 1998; Warren & Vincent, 2001).

**Limitations**
This study had limitations. First, the sample of 30 is not representative of all Black males attending large research-intensive institutions or all Black males in STEM graduate programs. Second, while the broader study from which this article’s data was drawn centered on participants’ current experiences as graduate students, this article focuses on their retrospective memories of childhood. While participants recapped history to the best of their ability, retrospective studies incur the risk of revisionist accounts. Third, participants’ experiences are historically bound and relate to their upbringing in the 1970s through 1990s. Finally, their experiences are likely related to many other factors (e.g., parents’ levels of involvement, parents’ educational levels and occupations, household SES, cultural orientations to schooling and education). Despite these limitations, the steps taken to ensure quality provide the researchers with confidence that the findings were sound across participants. This suggests that, at least within this study’s sample, Black male graduate students in engineering shared similar origins of STEM interest.

Findings

Several main themes emerged from this study: (a) family members help cultivate and maintain early interest in STEM; (b) teachers affirm and strengthen early interest in STEM; (c) early interest in math and/or science creates lasting pathways through STEM; and, (d) participation in play connects learning and early interest in STEM. Although there is overlap between and across the findings, the findings are presented separately for clarity.

Family members help cultivate and maintain early interest in STEM

The majority of participants in this study attributed their current progress in engineering to family members’ cultivating and maintaining their interest in STEM at early ages. This finding aligns with previous research positing that family members are children’s first teachers (Wright et al., 2016). Participants reported that family members helped them become interested
in math and science in ways that demonstrate involvement in students’ education from a young age, both in and outside of the classroom. For example, Jackson stated: “I have always kind of credited my success to the people around me than to myself. Even from a young age, I had parents that stressed education, especially my dad. That [pushing education] was a huge thrust of his.” Jackson’s father would assign him and his brother extra reading and math workbooks. This at-home academic enrichment led Jackson to compete with his brother for the highest grades, and ultimately landed him in advanced math courses in middle school. Similarly, Marcus mentioned that his parents taught him complex math concepts at home around the fourth grade: “My parents had basically started teaching me some of the higher-level things in math like fractions earlier at home. Doing that stuff at home just uh—that helped my growth.” Jackson and Marcus’s parents, who used their own knowledge of math and science to deepen their children’s education, were representative of those of many other participants. Parents recognized, pushed, and consistently affirmed their capacities to excel in math. From a community cultural wealth perspective, parents activated both familial and resistant capital. According to students’ stories, parents and family members shared the value of education as an equalizer for social justice. From that perspective, their encouragement to be strong in math and science could have been a form of resistance to a system that often keeps Black boys undereducated.

In addition to helping build competence in mathematics, family members facilitated an interest in science, often through science-related activities. Two participants described similar introductions to science. Joseph and Alphonso, now both doctoral candidates in engineering, mentioned how watching television programming and science fiction movies exposed them to STEM. Joseph recollected “always watching sci-fi movies.” Alphonso said, “I always, you know, watched TV…and you’d see these science fiction type things and that was always good.”
In addition, both discussed memorable trips to museums. Joseph stated that going to museums “[was] interesting, and cool…[My parents were] trying to stimulate intellectual curiosity through exposure.” Alphonso said, “Going to the Franklin Institute Science Museum in Philadelphia…and experiencing that, I think it was one of the big draws that…drew me into science.” For Alphonso, going to the museum was a consistent family affair. Alphonso’s cousin, also interested in science, would join them. Alphonso explained that he and his cousin would discuss what they saw at the museum, just as they did when watching science fiction television. For Alphonso, watching television and going to the museum appeared to be shared family experiences he looked forward to. He paints the picture of a young boy excited to learn with family about STEM. His story might be another example of aspirational capital where parents recognized STEM interest in Alphonso and his cousin and encouraged both of them. If so, this intentional linking of curious, creative, high-achieving Black boys relates to the work of Fries-Britt (2002), who asserts that high-achieving Black students thrive when they interact with other high-achieving Black students. Through activities such as watching television and attending museums, participants gained knowledge about science-related topics and deepened their interest in science outside of the classroom.

Similar to Jackson’s father, who encouraged extra reading and math assignments, Samuel’s father purchased science books for him. Samuel stated,

I relied on those books and then studied hard. I learned things from them. After the first semester [of high school], I started feeling comfortable and understanding things, so I just continued in [the] STEM [track]. Toward the end of high school, that's when I decided to go into engineering.

The books expanded his understanding of science beyond the high school curriculum and influenced his decision to major in engineering. While providing Samuel with readings outside of the standard school curriculum could be considered a form of resistant capital, as suggested
through the stories of Jackson and Marcus above, it appears that Samuel’s father activated navigational capital to assist him in feeling more comfortable and identifying with science.

Some parents illustrated navigational capital by working with schools to get their children into gifted math and/or science courses. For instance, as alluded to above, Marcus’s mother selected his courses for him: “She saw where I was [a strong student] in math, so she enrolled me in advanced math classes. You know, she took all the physics, the chemistry and the biologies…in high school, so she enrolled me in those.” In addition to his mother’s navigational wherewithal, her familial capital likely guided her decision; she holds a doctorate in a STEM field and knew he would need a strong math and science foundation in whatever career he chose. Jesse, similarly, recalled his parents working with administrators in elementary and middle school to get him placed in gifted math courses, a decision with which he was not initially pleased: “At the time I was not necessarily happy about it [being enrolled in gifted math courses], because it cut into recess. Looking back at it, I'm glad they did.” Jesse, now a fifth-year doctoral candidate in electrical engineering, acknowledged that the advanced math courses interfered with recess, an important activity for the socialization of young kids (Wright & Ford, 2016). David, too, was enrolled into a gifted program that ignited his interest in STEM. Like Jesse’s, David’s program allowed him to “be in the same classes with everybody else,” before “breaking off” to receive additional math and science. Unlike Jesse, David did not express disinterest in being removed from his peers. The findings related to the structure of advanced and/or gifted courses is worthy of mention. Specifically, being isolated from one’s peers because of academic aptitude is not always well received by students. For some Black boys, being gifted in science and math can be perceived negatively as attempting to be and/or act White, a put-down in the Black community (Fries-Britt & Griffin, 2007). However, now finishing the
doctorate (Jesse), halfway through it (Marcus), and just beginning (David), they all now recognize the necessity of gaining a foundation in mathematics at a younger age.

**Teachers affirm and strengthen early interest in STEM**

Like participants in previous research (Berry, 2008; Moore, 2006), the Black males in this study also referenced the roles their teachers played in cultivating and maintaining their interest in STEM. For example, Christian, a doctoral student in civil engineering, shared how he became interested: “I took chemistry 10th grade year and hated it because my teacher was not engaging. She did not make chemistry fun. It was just boring, but physics was fun. In physics you got to see how it works.” Although Christian mentioned that physics was more appealing because it was a science he could see, what is most germane in his quotation is the role of his science teacher in bringing to life complex material. Christian described the pedagogical delivery of his physics teacher as being engaging, making the class and learning physics fun, whereas his chemistry teacher was described as “boring,” which made chemistry less interesting to him.

From a community cultural wealth perspective, Christian’s physics teacher might have activated aspirational capital to help Christian see himself as a talented learner of physics, despite previous challenges in chemistry. Without his physics teacher in the 11th grade, Christian could have easily determined that he was not good at science. However, his story demonstrates the connection between educators’ presentations of course material and students’ likelihood of engaging with that material in ways that lead to sustained interest and participation in STEM.

The sociocultural context of schools is also worth noting with regard to developing several participants’ early interests in science and math. Logan, for example, shared that his early interest in STEM can be attributed to the aspirational community wealth of attending an Afrocentric school in a large, metropolitan city in the Midwest:
My interest in engineering actually came at the Afrocentric school that I went to. They made us take a career placement test which had hundreds of questions. I took that test and the top result for me was electrical engineering. I was like maybe 8 or 9 [years old] or so. I didn't know what [electrical engineering] was, but I went home I told my parents.

David also attended an Afrocentric school in a large, metropolitan city in the Midwest (different from the one described by Logan). David, too, explained the nature of his schooling experience, community cultural wealth, and its influence on his early science and math interests:

I went to [Afrocentric Academy] in [my hometown]. It was one of the earliest schools in America with African-centered curriculum, completely unapologetically Black. The curriculum was based around teaching our history, not just from the slavery aspect but the inventors, the poets, the artists, the contributions to society, learning Swahili, being exposed to a number of different things. So it was there where I learned. I was a part of the chess club. I was a part of academic games. I was a part of an electronics club. I participated in the aviation club, where I got to go and fly regularly at [a nearby high school focused on aerospace engineering]. It was a school that really nurtured whatever your interest was.

Apparent in this recollection is the familial cultural community wealth David accessed. Although the school personnel were not his biological family, African culture (the framework on which his school was based) is familial. Thus, the personnel at his school designed curricula and shared knowledge that connected to their community, culture, history, and STEM developing identity.

Both Logan and David indicate not only the importance of early STEM exposure, but the significance of the symbolic representation of those teaching STEM courses and the resources available to students at these schools. Having educators who affirmed their early STEM identities and made connections to their Black identity appeared to influence their early and sustained interest in STEM.

Although Christian did not attend an Afrocentric high school like Logan and David, he attended a demographically diverse high school. Christian described how the race of his math teacher mattered; he traced his current success in an engineering doctoral program to his
foundational math experiences, taught by a Black woman: “I had a very strong foundation in math and how to tackle problems. [My algebra teacher] was really good. She also happened to be a Black woman. I guess that is that representation thing and relatability.” Christian further explained that his teacher served as a “second mother” to him and encouraged him to apply for a scholarship to attend college. Christian’s story speaks not only to the early development of his math interest, but also to the importance of young Black kids seeing those who look like them practicing math and science. Additionally, Christian’s teacher’s affirmation of his early interest in STEM encouraged him to pursue a STEM-related major in college.

Taken together, these findings illustrate not only the role of exceptional teachers, but the effect that same race – and in some cases, same race and same gender – teachers may have on the origins of students’ interest in science and mathematics. Decades later, it is to these dynamic teachers that students trace their early interest in science and mathematics, further demonstrating the significant roles that teachers play in influencing students’ early interest in STEM.

**Early enjoyment in math and/or science creates lasting interest in STEM**

Data analysis also revealed how early enjoyment of math and science typically influenced students’ sustained interest in STEM. For example, in response to a question about how he first became interested in STEM, Jalen said, “I think everything started by being good at math. No, actually, no. I'm a naturally curious person.” Chris also admitted, “When I was young I was always interested in science.” Titus, a doctoral student in environmental and civic engineering, said his early interest in STEM dated back to his elementary school days: “I've actually always just liked math growing up. I can even remember back to elementary school, math was always my favorite subject. I guess that's probably what drove me towards engineering.” Participants mentioned how their enjoyment of math further drove them to pursue doctoral degrees in engineering. For Jalen, his competency in math and science was honed by, as he described,
“great teachers who were always encouraging, especially science and math teachers. I was exposed to computing, you know, fifth to sixth grade, and that's very rare especially among the Black community.” Shawn mentioned that his interest in math started in elementary school. He described a particular program that guided his interest in math:

I'm not sure if you're familiar with “Academic Games.” It's a competition. It starts as early as elementary school. They have it at the middle school and the high school level. It's not just a [State in the midwest] thing because I started in fifth grade and sixth grade is when I made it to a national tournament…nationals was in Georgia….In fifth grade, I made it to the state level, and then sixth grade my team made it to the national level. I guess as early as elementary school is when I knew I was interested in the STEM area.

Participating in the Academic Games led Shawn to realize his ability in and enjoyment of math and science. Further, this competition allowed him to recognize his level of competence on a national scale. Jessie, too, explained his enjoyment: “I really liked math. I've always liked math. As far back as I can remember I've been a fan of math, and math directly translates into engineering.” Like Shawn, Jessie also participated in a co-curricular program: a summer enrichment program. Clearly, these experiences provided additional self-efficacy, which over time made them more confident in majoring in STEM before pursuing their doctoral degrees.

**Participation in play connects learning and early interest in STEM**

Several participants recalled moments when they engaged in play, and how learning from those experiences encouraged their growing interest in STEM. Jalen directly connected his play as a young child to his interest in STEM:

As a kid I planted a lot of trees. I had animals. In fact, I was the only one to have animals in our family. I told my dad, "Hey, I want to have some chickens." I basically turned the entire yard into a farm with trees growing and you have animals just running around. I think if I pinpoint any point in my life that I was destined to be on this path or a similar path like this, I would attribute it to that.

Jalen revealed that as a child he pretended to be a medical doctor. Having trees and animals allowed him not only to care for those living entities, but also to be curious about the
mechanisms and factors that allowed them to thrive on his family farm in Jamaica.

Like Jalen, other participants recalled forms of play that helped build their curiosity for STEM. Joseph shared that playing with LEGO®s and building bridge structures made of toothpicks with a friend whose father was a civil engineer “was the first time that I really recognized that I liked looking at patterns and creating things and building things.” Joseph’s story is significant both because he built bridges with toothpicks and did it with a Black peer also interested in science, and because his peer’s father was Black, and a civil engineer. Being afforded the opportunity to see a civil engineer who resembled him in terms of gender and race contributed to his aspirational cultural wealth needed to pursue STEM pathways. Additionally, Joseph’s parents connecting him to a civil engineer illustrates their social capital, or access to those within their cache of community cultural wealth. In Joseph’s case, all of these factors are significant in the development of his early interest in STEM. Jacob, too, recalled “having fun” building structures with LEGO®s. The role of playing with LEGO®s, and other toys that assisted their interest in building, is consistent with existing research (Crowley, Barron, Knutson, & Martin, 2015).

As with Shawn and Jesse above, several students’ involvement in play took place outside their home and classrooms. Chris experienced it through a pre-college engineering program designed to increase the number of Black males pursuing STEM. This program used LEGO®s as an instructional tool to encourage interest in engineering. Jacob also experienced play outside of school in a summer program. He recollected:

There was a summer program where essentially we did experiments…dissected things…had science projects and all that type of stuff. It was the first time I remember having a ton of fun doing it. But again, it's probably more the Lego concept of putting something together and watching it work.
This quotation from Jacob, in concert with those of other students who participated in co-curricular and summer enrichment programs, emphasizes the importance of these resources in facilitating play-based STEM learning. Co-curricular enrichment programs gave them opportunities to explore and deepen their knowledge in math and science outside of traditional school curriculums and allowed them to nurture burgeoning identities in math and science. Additionally, these resources served as valuable sources of community cultural wealth that reinforced math and science, and nurtured students’ developing interests in STEM.

**Discussion and Implications**

Our findings align with those of previous scholarship on families, mentors, communities, and schools nurturing children’s self-efficacy, confidence, and desire to achieve (Maltese, Melki, & Wiebke, 2014; Whiting, 2006, Wright et al., 2016). The findings from this study suggest that successful Black males benefit from an “all-hands-on deck” approach. That is, cultivating and nurturing kids’ early STEM interests is not a parent versus teacher binary, but rather a community affair. Our findings reveal that a more expansive constellation of human resources should be accessed, including parents, teachers, siblings, and family friends. Everyone can be involved in helping develop and nurture students’ interest in math and science. It is also necessary to recognize overlaps across the findings. Family members and teachers offered their own unique efforts to encourage early interest in STEM, but they also encouraged learning from play (Crowley, Barron, Knutson, & Martin, 2015). This finding reiterates the multifaceted roles community members play in Black boys’ formative years with regard to developing an interest in and identification with math and science (Alexander, Johnson, & Kelley, 2012; Brown & Kelly, 2007). It is through this broader constellation of individuals and activities that Black males benefit from the wealth within their communities.
Our findings offer important extensions to existing research. First, the specificity of our findings to Black male engineering graduate students provides insight into an understudied population. This study’s focus on graduate students offers another nuance to the STEM pathway story for Black boys. These males have traversed K-12, and undergraduate studies in STEM, and now are completing the highest level of study for those interested in careers in STEM. Their retrospective perspectives offer bird’s-eye views of the P-20 pathway, and the ways that family and teachers helped them persist in STEM. Their perspectives offer a unique view of the long-term STEM trajectory of Black boys and men. Given the dearth of scholarship on the experiences of Black male graduate students in engineering (Burt, Williams, & Smith, in press; McGee & Martin, 2011), it is necessary to understand how current graduate students experience STEM pathways. Equally important, more scholarship is needed to understand how and why they became interested in STEM, and what resources they accessed and activated along the way. This is the first study that links the experiences of young Black boys to engineering graduate persistence. Thus, this article begins to address the inquiries needed to broaden participation in STEM.

Second, this empirical study draws upon a theoretical framework that is not often used in STEM or engineering education work. Yosso’s (2005) framework provided a lens by which to see how persistence in graduate STEM programs can be linked to early origins of Black males’ STEM interest. Their interests, related to their interactions with family, teachers, and activities that encouraged their early enjoyment in STEM, were forms of community cultural wealth not previously explored with the same theoretical depth as in this study. Now that we have a better understanding of how these interactions and activities (as forms of community cultural wealth) provide positive outcomes for Black boys, it is important to think about how those in boys’
communities can help them engage in meaningful interactions and activities. For example, not all children come from backgrounds where parents hold STEM degrees and engage in STEM occupations. Nor do all children come from backgrounds where frequent access to museums, and other forms of “play,” is possible (whether because of financial means or geographical proximity). Our findings on the role of boys’ collective community suggests ways that extended family members, and family friends, and teachers and school administrators can provide boys with necessary interactions and activities that will nurture sustained STEM interest.

In whole, our findings provide empirical and theoretical connections between childhood experiences in STEM and later STEM participation, and offer an example of how researchers might examine underserved populations in STEM in the future. While complementing previous research, the findings are not restatements of existing research, but rather offer more depth and nuance to the study of Black childhood education and its implications for graduate education.

**Implications for Practice and Policy**

This article highlights several opportunities for practices that can be used by a wide range of stakeholders (e.g., teachers, parents, family members, community members, administrators, faculty, policy-makers) (See Table 2).

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<th>Type of Influence</th>
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| Family           | • Intentionally engage children in science and math-related enrichment activities. Include discussions of learning after these activities.  
|                  | • Partner with schools to attend local events, museums, and other academic enrichment programs that will further expose students to STEM concepts.  
|                  | • Utilize family cultural wealth as sources of support, instead of solely relying on parents to nurture children’s STEM interest.  
|                  | • When children display early signs of STEM interest, advocate on the behalf of students by enrolling them in advanced or gifted courses in the math and science areas. These courses have the potential to set students up for future STEM pathways. |
| Teachers and Schools | - Expand considerations of the ways in which interest in STEM is expressed by Black boys. The earlier math and science interest is noticed, the better the chances of cultivating and maintaining their interest later on.  
- Intentionally deliver educational content in relation to math and science in ways that are culturally relevant to students.  
- Hire and retain more Black teachers teaching math and science subjects. They may see potential for STEM in Black boys in culturally specific ways that may be lost by others holding different social identities. Additionally, they may provide models of success in math and science for Black boys. |
| Policymakers | - Account for how many Black boys are placed into advanced and gifted education courses relative to other student populations. Where there are discrepancies, investigate how inequities in determining course placement arise.  
- Create academic enrichment programs (e.g., Saturday programs) focused on developing students’ STEM and racial identities.  
- Develop more hands-on, play-based learning activities which are culturally relevant and also incorporate current technology. |

For instance, it is clear that STEM learning occurs both within and outside of the classroom (Falk & Dierking, 2010; McGee & Pearman, 2014; Wright et al., 2016). Some of the activities that students participated in included in-home math and science-based activities; building LEGOs; trips to the museum; supervised viewing of science shows on public broadcast; summer science camps and workshops; and science competitions. Participation in these activities was often facilitated by parents, family members, and teachers. Their encouragement nurtured students’ early interest in STEM. For many of the males in the study, an early interest in math and/or science led to a deeper interest in STEM. Encouragement like that displayed in this study might help mediate potential discouragement from others who make Black boys feel an interest in science and mathematics is “nerdy” or “for White people” (Fries-Britt & Griffin, 2007).

Parents, family members, and teachers also created avenues for Black boys to participate in play-based learning activities. Learning while playing helped participants enjoy math and science while exposing them to STEM concepts. Based on this finding, more encouragement for
Black boys to play is needed. This is especially true today when it appears that Black boys are not allowed to just be kids, but rather are encouraged to grow up and be men (Henning & Davis, 2017; Ladson-Billings, 2011). Black boys should be allowed to tap into their creative and imaginative sides, both of which are facilitated by play (Alexander, Johnson, & Kelley, 2012; Brewer, 2007). Our data show that trips to the museum, tinkering with chemistry sets, watching science programming, constructing buildings and bridges with LEGOes, and other opportunities to build and tear things down were important. These activities helped students imagine future selves and possibilities in STEM. What appeared to be key, however, was an additional layer of intentional connection to math and science. That is, trips to the museum and math and science problem sets at home were accompanied by conversations with family members about learning. This added step deepened students’ understandings of the math and science embedded within their play. Today, play may take the form of video games on the computer, tablet, phone, or game console (Strayhorn, 2015). However, applying the findings from this study to newer technology may encourage similar results when there are follow-up discussions related to the math and science components of the games (e.g., angles, shapes, computing coding).

Given the amount of time teachers share with kids throughout the week, their experiences with Black boys are of immense importance. Unfortunately, an overwhelming amount of literature highlights the negative experiences had by Black boys in the classroom, largely due to negative stereotypes teachers hold of Black boys as deficient learners (Ladson-Billings, 1995; Martin, 2009). Based on the findings from this study, by attending Afrocentric schools, some participants eluded hostile environments where they might face negative stereotypes related to their race and gender. However, not all students can, or will, attend those types of schools. And based on current demographics, the majority of today’s teachers are White and female (Hancock
& Warren, 2017). However, that schools and teachers are not predominantly Black does not mean that curriculum and pedagogies cannot be culturally relevant. Rather, teachers must employ pedagogical methods that support the cause of developing and maintaining Black boys’ early interest in science and math (Moore, 2006). This can be achieved by affirming students’ Blackness throughout the curriculum, and through more culturally affirming teaching strategies. Recognizing and encouraging Black students’ promise in math and science can have positive effects on their academic achievement (Berry, 2008; McGee & Pearman, 2014). In addition, teachers can help make explicit connections between school work and career options. Helping students link their developing interests to potential professions provides them with more tangible ideas about their future selves and the necessary connection between achievement in school and future careers (Bartz & Mathews, 2001; Williams, Burt, & Hilton, 2016).

Implications for Future Research
This article also offers implications for future research. Research that highlights origins of students’ interest in STEM will provide new information with which to improve STEM pathways for underrepresented populations. This article begins to advance this research agenda. First, our findings illustrate a range of learning across the K-12 continuum. To gain more insight into the nuanced learning that occurs at various stages, future studies might explore the specific activities that students participate in at younger ages and educational stages (e.g., K-5, 6-8, 9-12). Examining types of activities by age and grade level may help parents, family members, and teachers improve programming options and play-based activities appropriate for students’ levels. Incrementally providing kids with more advanced forms of math- and science-based play over time may result in sustained interest in STEM; this hypothesis should be empirically tested. Alternatively, future work might explore the value of having parents, family members, and
teachers increase the intensity of learning-based discussions after play in an effort to scaffold greater learning and connections to math and science.

Second, future research should consider the roles that parental and family demographics (e.g., socioeconomic status, parents’ educational background, parental occupation) play in students’ early and sustained interest in STEM. In the present study, a majority of participants’ parents had postsecondary degrees, and some held advanced degrees and occupations in STEM, similar to the demographics described in other research on high-achieving Black males (Fries-Britt, 2017). These demographics may inform the types of students who become interested in STEM at early ages and eventually attend top-ranked engineering colleges and institutions. This is not to suggest that the higher the socioeconomic status, the more likely children are to pursue STEM; some students in the present study reported being raised in low-socioeconomic status homes. Thus, future research will want to investigate these demographics in more nuanced ways to determine if there are patterns of types of support across demographics, and how families can incorporate support regardless of demographics.

Finally, Yosso’s (2005) community cultural wealth framework provided a lens with which to begin looking at students’ communities as bastions of existing wealth. This framework centers the need to provide Black boys in STEM with structural support that can help buffer them against sociocultural forces that might otherwise inhibit their participation. It helped expand our analysis of what and who might be valuable resources that promote students’ success through STEM pathways. By applying this framework, we also aimed to empower communities that serve Black boys to understand that they already possess valuable tools that can help children reach the highest levels of academic achievement. However, future research could aid parents, families, and teachers in extending the application of this framework. That is, a focus on
forms of community cultural wealth that promote math and science participation could help engineering educators develop more precise tools specific to STEM.

A contribution this study offers is its retrospective look at participants who are surviving and striving in engineering graduate programs. Because of their persistence, these Black males are already role models for younger generations. They show what it looks like to be Black, male, and in STEM. This article provides important evidence of supports and resources needed for some Black males to navigate a field that they enjoy, but that also imposes barriers to their participation (Burt, Williams, & Smith, in press). Our findings acknowledge the lasting effects of cultivating and maintaining STEM interest, enjoyment, and identity. The participants in this study are graduate students, well into their 20s or early 30s, yet vividly recall critical experiences from their childhoods that set them on the course to STEM. This illustrates that what takes place during childhood undoubtedly influences STEM potential and possibilities. Thus, to broaden participation in STEM, we – as a community – must develop the interests, enjoyment, and STEM identity of young Black boys.

References


