

REVIEW ARTICLE

Potential engineers: A systematic literature review exploring Black children's access to and experiences with STEM

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Abstract

Background: As engineering remains central to the US economy, it is imperative that the innovators of this field reflect the world in which we live. Despite decades of concerted effort to broaden participation in engineering, representation continues to lack.

Purpose: The purpose of this paper is to provide education researchers and practitioners with a clear understanding of barriers to the participation of Black American children in science, technology, engineering, and mathematics (STEM). Our interest is driven by the role that precollege STEM experiences play in children's likelihood of becoming potential engineering students.

Scope/Method: We conducted a systematic literature review of 41 articles focused on Black children in precollege STEM contexts. Each article underwent individual review to gain deeper insight into key contextual factors that enable and constrain these potential engineers.

Results: We situate our research findings in Perna's college choice model to highlight the key factors that may influence one's career and college decisions. The contextual factors are associated with the (1) social, economic, and policy context (e.g., racism, sexism, and classism); (2) STEM educational and community context (i.e., social perceptions and access); and (3) the local support context (i.e., teachers and family).

Conclusions: Our results represent the early workings of a “glass ceiling” above the heads of potential engineering students. The underrepresentation of Black Americans who thrive in engineering is a byproduct of the lack of accessibility to quality and advanced learning experiences that too often plague K–12 schools and communities that serve high populations of Black Americans. Such findings have implications for research and practice.

KEYWORDS

discrimination, pre-engineering, race/ethnicity, socioeconomic status, systematic review, underrepresentation

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1 | INTRODUCTION

Despite continual efforts to broaden participation, there has been a decline in the percentage of engineering degrees awarded to Black Americans (Gibbons, 2009; Roy, 2019). We present the findings from a systematic literature review (SLR) exploring the precollege experiences that Black youth have with science, technology, engineering, and mathematics (STEM). Our interest is driven by the role that precollege STEM experiences play in children's opportunity to pursue engineering degrees upon graduating high school. Since the 1970s, various stakeholders have called for increased diversity in STEM (Carnevale et al., 2014; Griffin, 2018; Holloman et al., 2018). However, Black Americans, among many other groups, remain disproportionately underrepresented (Pew Research Center, 2018); this discrepancy is particularly evident in engineering, where only 4.2% of undergraduate degrees were awarded to Black/African Americans in 2018 (Roy, 2019).

We argue that the likelihood of producing a representative pool of engineering graduates will remain dismal if the country continues to lose students from underrepresented racial groups at critical points along the education-to-workforce pathway. Research shows that early access, exposure, and exploration to opportunities that individuals have during their primary and secondary educational experiences serve as strong predictors of their future success and career paths (Daugherty et al., 2014; DeJarnette, 2012; McClure et al., 2017). And though some students actively choose to pursue other career paths (e.g., Wang et al., 2013), the insufficient proportion of engineering degrees awarded to Black Americans cannot be attributed to a mere lack of interest and ability: This situation is a byproduct of the lack of accessibility to early experiences and exposure to STEM, which often acts as a gatekeeper to undergraduate engineering programs.

Although K–12 engineering education has begun receiving more attention lately (Mendoza Díaz & Cox, 2012; National Academy of Engineering, 2020; National Research Council, 2009a, 2009b, 2010), its lack of presence in most environments necessitates an approach that still views K–12 engineering education as interconnected to K–12 STEM education more broadly. This connection is evidenced in the literature that focuses on why engineering students have chosen their respective majors. Numerous studies, for example, document the relationship between undergraduate students' motivation and identity to their interest in and prior success with science and mathematics (Godwin et al., 2016; Jiang et al., 2020; Matusovich et al., 2010). The existence of this phenomenon influenced our broad scope. The work that has been done related to Black children's experiences with STEM is fragmented, in disparate bodies of the literature, and has not been synthesized. Thus, to fully understand and address the poor representation of Black Americans who complete engineering degrees, exploring trends of K–12 level STEM experiences is necessary.

1.1 | Purpose

The purpose of this paper is to synthesize the literature on the early experiences that Black children have with STEM to identify contextual factors that have implications for their pursuit of formal engineering and computer science (E&CS) education. Toward this aim, the research question guiding this inquiry is: *According to scholarly literature, what contextual factors most significantly influence the experiences Black children have with STEM?* We identified and analyzed 41 publications focused on this topic. The results of this SLR provide insights into how multiple contextual factors work together to create a “glass ceiling” of sorts preventing many Black children from becoming potential engineering students. In addition to presenting the results of our SLR, we also highlight future areas of research exploration as well as practice improvements.

2 | METHODOLOGY

The SLR is a methodological tool to review the state of the literature (Kitchenham et al., 2009; Paré et al., 2015). SLRs are most useful when scoping an unknown research area and identifying gaps from which to commission future research (Grant & Booth, 2009). While the literature does currently exist on the topic of broadening participation, it is often in disparate bodies of literature and is fragmented, and has not yet been synthesized. To make valid inferences about and recommendations toward improving participation trends, situating the work within an existing body of knowledge is key. Although SLRs have not traditionally been a typical method used in engineering education research (Borrego et al., 2014), other disciplines have found value in them for their ability to summarize, critically evaluate, and reconcile conflicting evidence to inform policy and practice (Borrego et al., 2014).

2.1 | Literature mapping

This study is a part of a larger project. Prior to beginning the review of the literature for the K–12 education segment, a process of literature mapping took place to identify and select eligible articles to be included in the entire first phase of a larger study. A systematic map “categorizes existing literature from which to commission further research and/or primary research by identifying gaps in research literature” (Grant & Booth, 2009, p. 94). As such, the results of a literature mapping process characterize the literature on a particular topic by documenting trends surrounding features of study designs (London et al., 2020). While literature reviews and literature mapping have many overlapping characteristics, some of the main differentiators of the two methods are related to (1) research objectives and question formation; (2) search strategy and article screening; (3) data extraction and critical appraisal; and (4) synthesis and reporting (James et al., 2016; London et al., 2020). In short, literature mapping is the step that aids in the creation of a database of literature for an actual literature review process.

For this study, the literature mapping process followed an adapted version of the PRISMA checklist (2009). Figure 1 (below) illustrates the process of starting with a large pool of potential sources to be reviewed, and narrowing them down to those that were included in the SLR. To be included in the SLR, the relevance and academic merit of each

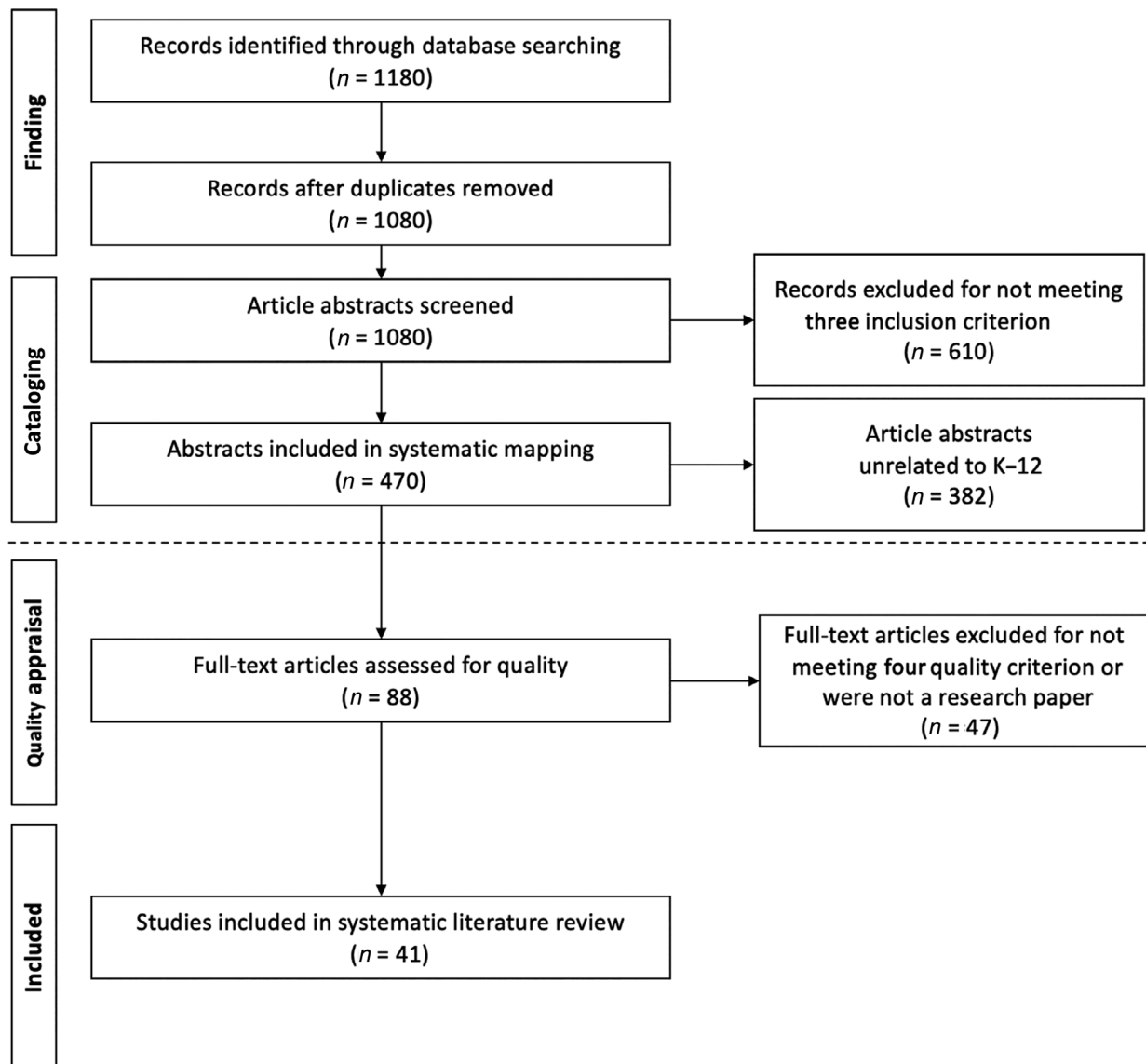


FIGURE 1 PRISMA diagram depicting the process of identifying, cataloging, and appraising the literature included in the systematic mapping

article were assessed by multiple members of the research team and evaluated on the following criteria: (1) are the problem/purpose/aim of the study clearly articulated, (2) information about the data collection procedures was apparent and appropriate, (3) is the information and approach to analyzing the data appropriate to addressing the current project's purpose, and (4) was the sampling strategy appropriate and representative of the target population (Black/African American) for our work.

2.2 | Setting inclusion criteria and identifying sources

The initial inclusion criteria used during the collection of literature are as follows: (1) publication date range, (2) database selection, and (3) search string selection. This paper is part of a larger project, and more about these processes can be found in a previously published article about the overall process of conducting an SLR (London et al., 2020). These data were collected in January 2018. The beginning of the date range associated with this dataset (e.g., 1970–2017) was informed by historical events associated with efforts to broaden the participation of Black Americans in E&CS, specifically the establishment of several national-level efforts focused on broadening participation in engineering in the 1970s (e.g., National Action Council for Minorities in Engineering, Inc. [NACME] established in 1974 and the National Society for Black Engineers [NSBE] established in 1975). With the help of a librarian, databases and search strings were identified, as illustrated in Table 1. They helped limit publication bias by keeping the database options as wide as possible. Additionally, their expertise was used for identifying search strings, alongside input from researchers in our professional network and keywords associated with “Diversity” from the *Engineering Education Research Taxonomy* (Finelli et al., 2015).

After removing 100 duplicate publications, 1080 articles were evaluated against three additional hierarchical inclusion criteria: (1) Is the article written in English and about education or the STEM workforce in the United States? (2) Is the article focused on engineering or computer science in any context, or STEM disciplines in a K–12 context? (3) Is the article focused on issues or the experiences of Black Americans, or on some aspect of the wide variety of topics associated with broadening participation? Criteria 3 allowed for the inclusion of publications that might not focus solely on Black Americans. This inclusion was done to account for the possibility of learning from publications that emphasized Black Americans without solely focusing on them. We intended to be mindful of the realities of targeting a specific group, given the legal landscape of the early 21st century and the frequency with which multiple marginalized groups are included in a single intervention. In total, 470 of 1180 (40%) articles met the criteria and

TABLE 1 Databases and search strings used to locate articles

Database name	Search string	Note
Education Source and PsycINFO (EBSCOhost interface)	((bias OR discrimination OR multicultural* OR inclusive* OR racism OR prejudice) OR (motivation OR attainment OR achievement OR aspiration OR persist* OR retention)) AND ((AB african w2 american OR SU african w2 american OR TI african w2 american) OR (AB black OR SU black OR TI black) OR (AB people N2 color* OR SU people N2 color* OR TI people N2 color*)) AND ((AB STEM OR SU STEM OR TI STEM) OR (AB engineer* OR SU engineer* OR TI engineer) OR (AB “computer science” OR SU “computer science” OR TI “computer science”))	Search all fields for words used to include or exclude people Search Abstract, Title, Subject headings for terms used for African American Search Abstract, Title, Subject headings for STEM, engineering, and computer science
Compendex and INSPEC (Ei Village interface)	< ((motivation OR attainment OR achievement OR aspiration OR persist* OR retention) WN All fields) > OR < ((bias or discrimination or multicultural* or inclusive* or racism or prejudice) WN All fields) > AND < (((african ONEAR/2 american) WN KY) OR ((black) WN KY)) OR ((people NEAR/2 color) WN KY)) > AND < ((STEM OR engineer* OR “computer science”) WN KY) >	Quick search, Auto Stemming off, Search all fields Search Subject/Title/Abstract, Auto Stemming off Search Subject/Title/Abstract, Auto Stemming off

spanned across the education-to-workforce pathway, as illustrated in Figure 1 (additional details about the information in Table 1 are included in a systematic mapping review that has been published elsewhere; London et al., 2020). This paper focuses on a subset of 41 articles related to K–12 education.

2.3 | Preparing for the review of the literature

Of the 249 articles deemed eligible for review during the data extraction process, 41 articles focused on Black Americans' experiences with STEM at the K–12 level. Once all articles to be included in the SLR were identified, each article underwent individual review to gain deeper insight into what researchers focus on when it comes to understanding the experiences that Black Americans have with STEM at the K–12 level. This article examination was guided by six overarching questions. The questions are as follows:

1. What research questions are researchers asking? What are the themes among the purpose and research questions of existing studies? In short, what are people studying?
2. What research methods, evaluation methods, and theoretical frameworks have been used to study issues of broadening participation of Black Americans in E&CS?
3. Who are researchers including in studies on broadening participation?
4. What are the limitations of studies on broadening the participation of Black Americans in E&CS, according to those explicitly stated by the authors of publications and reports on this topic?
5. What are some of the problematic things we saw? For example, are some topics getting much more attention than others? Are there things that are consistently missing from studies in this area?

These questions were answered for all 41 articles included in this SLR. The answers were synthesized into the themes presented in the next section. A summary of each of these articles can be found in the table in the Appendix.

3 | RESEARCH FINDINGS

We situate our research findings in Perna's college choice model (Perna, 2006), which presents the relationship between a student's context and college choice. The multilayered context depicted in this framework encompasses the social, economic, and policy context; the school context; the family context; and the individual's internal context. Collectively, it highlights the educational, psychological, sociological, and economic elements of context that impact college choice, and ultimately, student success. Our rationale for situating our findings in this model is twofold. First, the choice of engineering as a potential career path cannot be decoupled from the choice of a college, due to the central role that a bachelor's degree plays as the minimum credential required for entering the engineering profession. This framework highlights the key factors that may influence that decision. Second, the themes that emerged during this SLR analysis are comparable to the constructs in Perna's model. Because our themes were identified prior to the selection of this framework, this alignment provided further external validity and theoretical support for the appropriateness of this framework. Consequently, Perna's college choice model will serve as the organizational framework for this study's findings and the bridge between this SLR's findings and existing scholarship.

As research indicates that early exposure to STEM experiences is key to ensuring young people are adequately prepared to pursue engineering career paths, there are a host of factors that can influence their trajectory toward E&CS. Among the articles included in this SLR, the questions explored and methods within these studies varied greatly. Thus, we were unable to identify any patterns among their aims or research questions. However, we did identify themes related to the factors associated with early STEM experiences that influence students' interest and further exploration. These themes have been organized under three headings: (1) social, economic, and policy context; (2) STEM education and community context; and (3) local context. The first theme focused on issues of racism, sexism, and classism in light of college/career aspirations and choice. The findings associated with the second theme correspond to issues of social perceptions and access to STEM activities. Finally, the findings corresponding to the last theme are related to educators and family in the learner's life. Figure 2 succinctly presents these themes in light of Perna's model (2006).

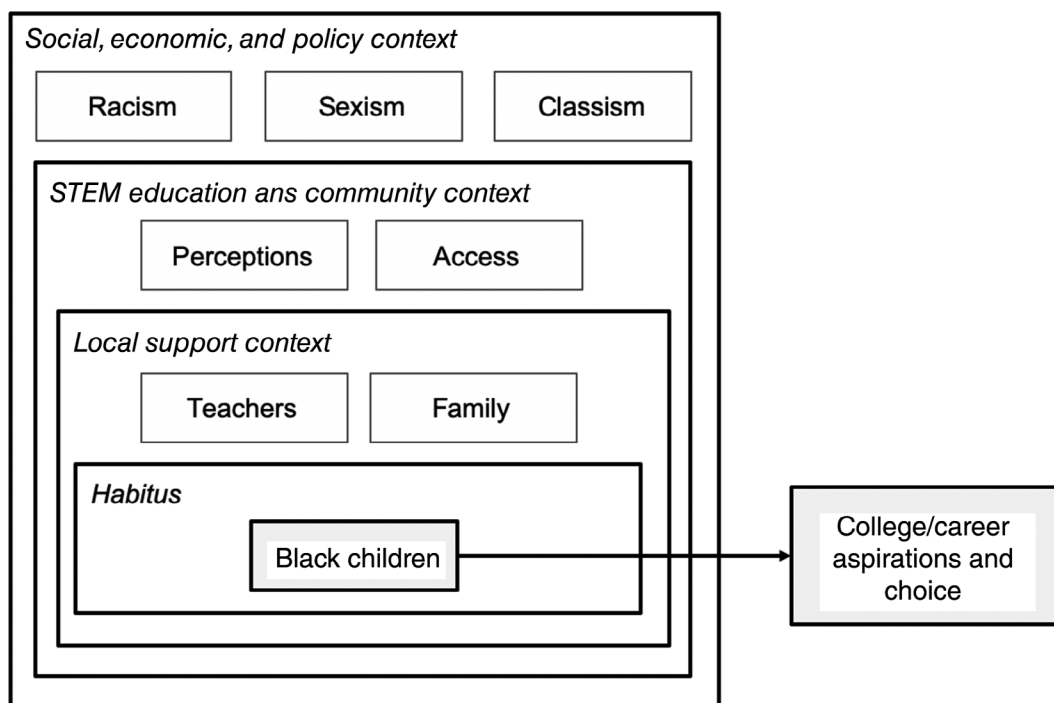


FIGURE 2 Themes from the systematic literature review situated in Perna's college choice model

3.1 | The social, economic, and policy context

Examining the underrepresentation of Black Americans in E&CS requires an understanding of the social, economic, and policy context as it relates to K–12 schools and communities. Since the establishment of the common school (De Lissovoy et al., 2015), racism, classism, and sexism have served as systemic gatekeepers to the level of access and quality of education that each individual receives. Particularly with regard to Black Americans, each of the aforementioned social structures continues playing a part in social stratification. The following subsections will give particular attention to how scholars have studied these structures with regard to Black American children's early STEM experiences.

3.1.1 | Race and racism

Given the nature and context of the larger project in which this study is situated, all articles included in this review used race as a focus of the investigation. However, the ways the authors approached race (or racism) varied. A large portion of the articles solely focused on the experiences of Black Americans (Brown et al., 2017; Carr, 2015; Cottledge, 2013; Diemer et al., 2016; DiSalvo, 2012; Fries-Britt et al., 2012; King, 2013; Lartson, 2013; Lattimore, 2005; McGee & Pearman, 2015; Moses-Snipes & Snipes, 2005; Olszewski-Kubilius et al., 2017; Polman & Miller, 2010; Robinson et al., 2016; Sharpe, 2011; Showers, 2015). In cases where there was a mixed representation of participants from the major race/ethnicity categories (e.g., Black/African American, White, Native American/Indigenous, Latinx, Asian/Pacific Islander), researchers often made comparisons of achievement and participation between Black Americans and their White counterparts (Andersen & Ward, 2014; Bowe, 2012; Cheong et al., 2004; Else-Quest et al., 2013; Mau et al., 1995; Palardy, 2015; Teague, 1994; Tolbert & Douglas, 2016). In a few cases, researchers had a heterogeneous race/ethnicity participant pool, but their study had a primary focus on results for Black Americans (Dickerson et al., 2014; Ramsey, 2012). These sampling trends could be attributed to the fact that for the last 40 years many researchers have been particularly interested in broadening participation of Black Americans in engineering and STEM as representation remains chronically low.

Many authors studied how race serves to moderate attitudes and self-efficacy around achievement in STEM (Bowe, 2012; Lattimore, 2005; Mau et al., 1995). One example of this is Lattimore (2005), where the researcher

concluded that Black children often feel inadequate when it comes to high-stakes testing in STEM-related subjects based on one-on-one interviews with them. Similarly, Scott and Martin (2014) found that the most frequently perceived external barrier (45%) was students' fear of being treated differently based on their race. Sato (2013) contends that despite schools' supposed status of being a place of equal opportunity, youth are often impacted by racism, bias, and discrimination, which often serve as barriers to STEM aspiration and participation.

While many of the investigators for these studies hypothesized and/or grounded their study in the idea that the status of being Black would impact students' beliefs about abilities, interest, and achievement in STEM (Carr, 2015; Else-Quest et al., 2013; King, 2013; Mau et al., 1995; McGee & Pearman, 2015; Robinson et al., 2016; Sato, 2013; Snipes & Waters, 2005; Teague, 1994), it was surprising to find that in some cases students did not feel their race served as a barrier. In their study of psychosocial factors that contribute to the underrepresentation of Black boys in mathematics courses, Rowlett (2013) found that five of the six participants adamantly dismissed the notion that racism played a part in Black Americans being underrepresented in advanced math courses. Such findings are important to consider as the field of engineering continues looking for ways to combat racism.

3.1.2 | Gendered racism and sexism

In addition to exploring the impact of racism, it is also important to consider how gender impacts these racialized experiences. Of the 41 articles included in this literature review, nearly half specifically examined the role of gender. Seven articles focused on girls (Carr, 2015; Cornick, 2012; Mau et al., 1995; Robinson et al., 2016; Teague, 1994) and six articles focused on boys (Brown et al., 2017; Cottledge, 2013; DiSalvo, 2012; DiSalvo et al., 2014; King, 2013; McGee & Pearman, 2015; Rowlett, 2013). In other articles, both boys and girls were included, while a significant element of the findings focused on gender-based differences.

Black girls and STEM

In some authors' investigations about how the intersection of race and gender impact girl's experiences, the main focal areas were on the factors that shape their attitudes and interests (Cornick, 2012; Mau et al., 1995; Robinson et al., 2016; Teague, 1994) and variables on STEM achievement evaluations (Carr, 2015; King, 2013; Ramsey, 2012; Teague, 1994). With regard to factors that shape girls' earliest attitudes and interests toward STEM, Cornick (2012) found that Black girls' ability to identify as an engineer was largely influenced by “1) self-efficacy beliefs, 2) academic identity, 3) social identity, 4) engaging learning experiences, and 5) support and encouragement from teachers and parents” (p. 136). They also found that interest in participating was influenced by school culture, expectations and values, encouragement to participate from others, and career aspirations. Likewise, Mau et al. (1995) found that girls' aspirations to pursue STEM careers were highly influenced by the encouragement of others. And Cornick (2012) found that experiences that girls have in middle and high school influence their perceptions of their ability to be successful in STEM. From the pre-program survey that Robinson et al. (2016) administered to their middle school program participants, they found that some students did not have high beliefs about their ability to do computer science well. However, despite their near certainty to underachieve in the content, the research team realized that many students did not even have a clear understanding of what computer science was. After the workshop, participants had higher confidence in their ability and interest in computer science. Findings from both of these studies affirm the earlier stated impact of early exposure on STEM interest.

Black boys and STEM

When studying the STEM experiences of Black boys, authors mostly investigated how these children navigated their identities with regard to STEM interest. All studies that focused on boys studied them at the high school level. In works led by DiSalvo (2012) and DiSalvo et al. (2014), the studies' purpose was to understand why, despite Black children often playing video games, that interest was not translating into a pursuit of computer science at the same rate as White and Asian American students. In their 2014 study, DiSalvo and colleagues asserted that Black boys often adopted a “cool pose” in their approach to education, as a way to save face and not indicate their peers they were overly smart or what would be considered “a nerd”—a stereotype often associated with both E&CS. They suggested that the cultural values of being “cool” and showing interest in STEM often conflicted. However, they found that interventions around their interest ignited an interest in learning computer science, and allowed them to do so, while still fitting in with peers. While DiSalvo saw Black boys as not seeing learning computer science as an intrinsic value, other researchers

have highlighted the various ways Black youth navigate the intersection of being Black and male (Brown et al., 2017; McGee & Pearman, 2015; Rowlett, 2013) and how they overcome these differences to attain achievement in STEM.

Recognizing the many social constructs in place to keep Black boys out of STEM, Brown et al. (2017) examined and documented how one urban school used representational practices to promote positive science identities within Black boys. They found that when the school made intentional efforts to create a culture that connected ethnic/racial identity and achievement ideology, it positively resonated with the young men. While their findings could not produce empirical indicators of how representation and positive identity aligned with STEM achievement, they did find that this type of framing was useful. Aligned with this correlation, McGee and Pearman (2015) found that positive social environments for Black boys provided an avenue for high achievement in math and science. Jones (2007) asserts that in order for race to no longer serve as an early barrier for STEM participation, educators and policymakers must continue to interrogate differential achievement outcomes between Black and White students.

3.1.3 | Classism

To fully understand how race functions in the United States, one must also consider the role of class or socioeconomic status as it relates to the underrepresentation of Black Americans in E&CS. Parsons et al. (2005) stated that the low-income designation is often a stipulation of these types of studies because those communities are commonly perceived to be isolated from mainstream American and hold a strong commitment to Black cultural ethos (BCE). Thus, many studies that focused exclusively on Black children also included an element of research that focused on those from low-income homes or low socioeconomic status communities (Andersen & Ward, 2014; DiSalvo, 2012; Lichtenberger & George-Jackson, 2013; McGee & Pearman, 2015; Tolbert & Douglas, 2016). Through many of the studies in this review, it was concluded that students' home and community socioeconomic statuses have a significant correlation to their early STEM experiences. However, the impact of socio-economic status (SES) also shows up in the learning environment. Because these two are often hard to distinguish, we discuss them both simultaneously.

Personal and community economic status

Research suggests that students with low SES are often subject to limited opportunities (Carr, 2015; McGee & Pearman, 2015). For example, McGee and Pearman (2015) assert that it is important to take note of the byproducts of being from a low SES background, such as limited transportation, having to care for family members, and the dangers associated with one's surrounding neighborhood may hinder access to opportunities. Research also documents that across the nation, learning environments for students, particularly Black children in underserved communities, are heavily impacted by the residual effects of low SES (Anderson, 2012, 2016; Darling-Hammond, 2010). More specifically, the nature of a student's learning environment can serve as a vehicle for directing their academic interests (DiSalvo, 2012; Moses-Snipes & Snipes, 2005; Parsons et al., 2005; Polman & Miller, 2010). While many studies found that SES was a significant indicator of strong participation in STEM, Andersen and Ward (2014) found that SES did not always serve as a strong predictor. Nonetheless, engineering must address the ways SES impacts students' access and entrée into opportunities that lead to those fields.

Recognizing the limitations that coming from a low SES background have on academic and social outcomes, Tolbert and Douglas (2016) found that, on average, students who attend a school with more students on free and reduced lunch had lower scores on precollege engineering concepts than those who attend schools with fewer free and reduced lunch receiving students. Similar trends were found by Lichtenberger and George-Jackson (2013), whose findings indicated that students who were in the college prep program, which is often associated with "White-collar" status, were more likely to have STEM aspirations than those on the career technical education track. Additionally, Teague (1994) found that Black girls are oversaturated in schools with limited resources.

In DiSalvo's (2012) study of how participation in an extracurricular STEM program impacted student interest, he found that program participation positively correlated to students' interest in computer science. However, an unfortunate reality for these students who had newly developed an interest in studying computer science is that of the eight different high schools the participants represented—*none* offered intermediate or advanced level computing courses. This finding aligns with other literature stating that schools with higher percentages of students who qualify for free/reduced lunch often lack advanced educational curriculum and resources; they tend to offer vocational rather than academic course work, including advanced STEM and computing offerings (Goode et al., 2006). It also aligns with findings from

Sato's (2013) study, where youth indicated that they experienced racism through the denial of high-quality classroom instruction and the ability to participate in science classes and experiences beyond those required for graduation.

Another factor that often plagues schools in low socioeconomic communities is overcrowding and large class sizes, which produce various problems for educators. For example, Lichtenberger and George-Jackson (2013) found that “class size was significantly and negatively related to one’s likelihood of planning to major in a STEM field. That is, students from schools with smaller class sizes had higher odds of an early STEM interest as compared with those from schools with larger class sizes” (p. 29). Sato (2013) also found that class size impacted students’ early experiences with STEM. And Sharpe (2011) found that Black children were more likely to exhibit high student achievement in mathematics when there was a sense of safety within the school—a classroom attribute that is undoubtedly easier to deliver in educational environments that are not overcrowded.

While issues such as income inequality and poverty might seem unrelated to engineering education, these studies highlight the significant impact that such issues have on Black children’s ability to excel academically in STEM and become potential engineering students.

3.2 | The STEM education and community context

In addition to understanding the social, economic, and policy context, it is also important to consider the STEM education and community context as it relates to Black children. The following subsections will give particular attention to social perceptions about deficits related to STEM ability and achievement and discuss access (or insufficient access) to STEM activities. What these findings highlight is that Black children’s self-perceptions, motivations, and identity formation regarding STEM are socially constructed and informed by cultural milieu. For students to be able to identify as future engineers within the classroom, they must be able to envision themselves fulfilling similar STEM roles.

3.2.1 | Social perceptions of deficit

When exploring factors that shape students’ early experiences with STEM, authors often acknowledge the fact that there is a deep-rooted social perception of deficit that influences Black Americans’ entire communities and thoughts around math and science ability—two skill sets often associated with a child being a potential engineering student. Recognizing how this narrative can work toward stifling children’s thoughts about their own ability to achieve STEM-related courses or self-identify as a scientist or future engineer, many researchers approached their investigation with the intention to debunk cultural deficit theories through the use of theoretical frameworks such as critical race theory, ecological systems theory, and social capital theory (Carr, 2015; Cottledge, 2013; DiSalvo et al., 2014; Drazan et al., 2015; Jones, 2007; King, 2013; McGee & Pearman, 2015; Palardy, 2015; Parsons et al., 2005; Polman & Miller, 2010; Rowlett, 2013; Sato, 2013; Sharpe, 2011; Showers, 2015; Snipes & Waters, 2005). For example, Jones (2007) highlighted that children are aware of how Black Americans’ representation in society, particularly around STEM, is often shaped by cultural biases that impact students’ academic achievement and career aspirations. For example, one child participant in their study noted that they had known people (Black Americans and non-Black Americans) to state preferences for White doctors, suggesting that Black doctors are less qualified. Their findings suggest that such perceptions and biases around Black Americans’ ability can impact students’ aspirations toward STEM-based fields, such as medicine or engineering.

Many other studies found that the intrinsic motivation to pursue STEM was negatively impacted by students’ feeling of not being good enough and not feeling academically prepared (Bowe, 2012; Carr, 2015; Cornick, 2012; Cottledge, 2013; Dickerson et al., 2014; Jones, 2007; Robinson et al., 2016; Snipes & Waters, 2005). An example of this was found in Scott and Martin’s (2014) study on students’ perceptions toward pursuing STEM in higher education. In the study, researchers conducted a survey and focus groups to measure students’ perceptions of internal and external barriers to STEM aspirations. They found that the most frequently perceived intrinsic barriers to students having STEM aspirations included feeling not as smart as other students (46%) and not feeling prepared enough to succeed in STEM (41%). Carr (2015) also found that when students performed poorly in math, it negatively impacted their self-esteem, leading to limited interest in STEM and prevented them from further pursuing STEM activities. Jones (2007) concluded that low test scores and fewer career choices in STEM, in comparison to those of White students, have resulted in lower interest and underrepresentation of Black Americans who participate in STEM activities in high school.

Comparatively, many authors found that when students had high achievement in math and science and/or positive thoughts about their ability to succeed, they had a higher interest in STEM (Bowe, 2012; King, 2013; Lichtenberger & George-Jackson, 2013; Mau et al., 1995; Showers, 2015). While many authors found that high achievement and positive thoughts around one's ability were strong predictors to interest in STEM, Cornick (2012) found that even when students did perform well in STEM there was not always a correlation with a desire to continue on the STEM pathway.

While children's beliefs about their STEM ability and achievement are important, these beliefs themselves are insufficient as it relates to broadening participation in engineering and largely influenced by the surrounding context. For example, Jones (2007) found that students' desires toward STEM were negatively impacted by the limited representation of Black Americans in science-related positions (e.g., doctors, engineers), causing them to question whether such a career is attainable. While none of the studies in the literature focused particularly on the role of media, participants highlighted the role of media in their exposure, or lack thereof, to STEM in some of the qualitative studies. One participant in Jones' (2007) study stated that their interest in STEM is influenced by watching television shows about doctors and nurses, which makes the healthcare profession "seem fun." Other authors found that the portrayal of Black Americans in the media, whether positive or negative, influences students' early interest in STEM (Carr, 2015; Cornick, 2012; Jones, 2007; Rowlett, 2013; Sato, 2013). Given the disconnect between students' sense of ability to participate and achieve in STEM within the school setting, and the prominent influence of media portrayal on STEM interest, broadening participation efforts must have varied approaches to make multi-angle touchpoints. Unfortunately, television shows that positively spotlight engineers in a way that makes the profession "seem fun" are few and far in between.

3.2.2 | Access to STEM activities

Through intentional efforts, educators can positively influence children's intrinsic motivation and self-efficacy toward math and science. For example, Bowe (2012) found that students having positive emotions about their ability to achieve in science had strong positive correlations to achievement. One way that educators work to enhance students' positive emotions in relation to STEM was through nontraditional (e.g., informal learning, out-of-class learning) STEM experiences. Accordingly, in the literature reviewed, there was a subset of researchers who conducted studies that explored how nontraditional STEM exposure could lead to positive associations with STEM (Carr, 2015; Cornick, 2012; DiSalvo, 2012; DiSalvo et al., 2014; Drazan et al., 2015; Olszewski-Kubilius et al., 2017; Polman & Miller, 2010; Robinson et al., 2016; Sato, 2013).

Researchers observed and interacted with children participating in afterschool, summer, and/or enrichment programs to understand how nontraditional STEM exposure influences larger STEM goals. Drazan et al. (2015) recognized that introducing Black, Latino, and Indigenous Americans to STEM could serve as a way to reduce poverty in low-income communities. However, this research team acknowledged that these groups are traditionally alienated from STEM altogether—engineering not being an exception. One approach that this team used to increase exposure and interest was finding a nonscience activity that the student and a scientist-educator already had a common interest in, such as art or sports. Once the science-educator and the student developed a trusting relationship, the two could then investigate their common activity through a scientific lens. Drazan et al. (2015) found that because the students were engaged in an activity in which they already had a natural interest, they were more comfortable being guided through the activity by the scientist-educator. They found that this allowed learners to feel a sense of "ownership" over the activity, allowing for an educator to enter into the children's circle of support in a more authentic way.

Researchers also found nontraditional STEM exposure beneficial in a project called Project Excite, a program that provides elementary through high school students with a cadre of math and science supports to close the STEM achievement gap. In their study, Olszewski-Kubilius et al. (2017) found that within their respective state, Program Excite participants outperformed nonparticipants on the Illinois Standards Achievement Test. According to their findings, it is suggested that front-loading programs and supports in nontraditional settings can support in nurturing students' interest and increase overall representation in STEM pursuits (Olszewski-Kubilius et al., 2017). This result is promising for those offering nontraditional experiences focused on engineering.

Another study that explored the impact of nontraditional education opportunities on STEM participation focused on a group of students who served as video game testers during a summer employment experience. DiSalvo (2012) sought to understand why young Black boys play digital games frequently yet were not leveraging that gaming activity into an interest in computer science at the same rates as their White and Asian American peers. He found that when

the Black boys participating in his Glitch Game Testers program were given the opportunity to play and contribute to the development of video games, they had an increased interest in computer science. Like Drazan et al.'s findings, DiSalvo (2012) also found that participants had a preference for learning and participating in STEM activities when they considered the experience to be more authentic. It was found that participants overwhelmingly planned to graduate high school, and the Glitch program seemed to “have had a significant effect on participants' intentions to take computing classes ‘next semester’ ($p = 0.01$) and ‘as many classes as possible in computing every semester’ until they graduated ($p = 0.19$)” (DiSalvo, 2012, p. 104). Such results are supported by Austin (2010), who asserts that the relationship between advanced math and science courses that students take in high school, and their early interest in STEM, has an impact on STEM degree completion.

The above findings remind us that in traditional school settings, Black children often lack access to the required STEM courses that would set a strong pathway into engineering or computer science degrees, necessitating non-traditional means of exposure to these fields and skills are important. Unfortunately, access to STEM activities similar to those mentioned above is not equitable, as noted by Tolbert and Douglas (2016) who state that many students' STEM disadvantages are due to the fact that students from lower SES and racially diverse schools have less informal (outside of school) exposure to relevant opportunities. This lack of access is often a direct result of the poor socioeconomic status of schools that disproportionately serve high populations of Black children.

3.3 | The local support context

Lastly, it is important to consider the significant role that other people had in influencing Black children's interest and participation in STEM. In particular, the studies included in our SLR found that children's interactions with teachers and family were key indicators of their interest and success in STEM education and career pursuits.

3.3.1 | Teachers

Teacher support and vested interest in students' success serve as key contributors to both positive and negative STEM experiences (Brown et al., 2017; Carr, 2015; Cornick, 2012; Drazan et al., 2015; Fries-Britt et al., 2012; Jones, 2007; Parsons et al., 2005; Showers, 2015). The various ways teachers served as an influence was through the social (either positive or negative) nature of feedback and exchanges with students (DiSalvo et al., 2014; Jones, 2007; Showers, 2015). Researchers who studied the significance of the student–teacher relationship on STEM interest found that students made positive associations between their teachers and STEM experiences when teachers affirmed their abilities in math and science (Cornick, 2012; King, 2013; Lattimore, 2005; Showers, 2015). Additionally, Cornick (2012) suggests that teachers must allow students to engage in engineering experiences outside of the context of the classroom, and create opportunities for additional communities of practice to develop that allow students to experience engineering in a variety of ways.

In Lattimore's (2005) work, a good teacher is described as one who is concerned about their students on a personal level, and is interested in and exercises willingness and patience to help students learn math. As a related example of this finding, one participant in Showers' (2015) study decided to forgo an advanced math class to remain working with the teacher (her first Black teacher) that made them feel supported and inspired. In parallel, Fries-Britt et al. (2012), Sato (2013), and Showers (2015) found that teachers who were negative or invalidating had equally powerful and lasting impressions on students. One noteworthy finding on how teachers can negatively impact students' STEM aspirations is through their own negative messages about math. Lattimore (2005) asserts that when teachers express their own difficulty with or apprehension toward math, that mindset is passed on to students. It is reasonable to assume that the same could be said for engineering.

With regard to teachers' direct impact on Black children's early STEM experiences, some authors examined the correlation between student outcomes and teacher attributes such as demographic variables, number of years teaching, level of credentials, and so forth. Lichtenberger and George-Jackson (2013) found that “students from schools where the teachers had higher aggregate academic qualifications were less likely to have an early interest in STEM, whereas students from schools where the teachers had more experience were slightly more likely to have an early interest in STEM” (p. 31). They further found that teacher academic qualifications had a negative relationship with an early interest in STEM, and teacher experience had a small but significant positive relationship. Contrarily, Cottledge (2013)

did not find a significant association between teacher demographic factors and certification on student performance. Palardy (2015) similarly found that even though Black and Hispanic children were slightly less likely to be taught by a highly qualified teacher, that inequity did not significantly contribute to achievement gaps (in math and science). Even if teacher factors such as certification, years of teaching, and other demographic factors do or do not impact children's aspirations or achievement, Tolbert and Douglas (2016) argue that "well designed professional development could have an impact on student knowledge and engineering identity" (p. 3).

One way some researchers found that teachers can work to make early STEM experiences more positively accessible for students is through using culturally relevant pedagogical practices. According to Parsons et al. (2005):

Some contend that the incorporation of culture directly enhances learning in several ways. The incorporation of culture makes cues more discernible, activates cognitive processes such that relevant components of a task are identified, and heightens the salience and meaningfulness of the situation to individuals so they become more attentive and motivated. (p. 194)

Aligned with the abovementioned finding, DiSalvo et al. (2014) and Fries-Britt et al. (2012) found that when teachers make lessons more engaging and allow students to participate in activities that align with their identities and interest, Black children's positive associations with STEM were developed. Although Fries-Britt et al. (2012) had a small sample size in their case study, it was found that when BCE was incorporated into the learning context, students showed greater improvement in STEM-related classes. "In the BCE-incorporated instructional context, 46% had average to good improvement" (p. 193). One point in the literature that highlights why and how culturally relevant pedagogy can serve as a key to minimizing barriers toward Black Americans' early participation in STEM is through this final example from Parsons et al. (2005):

When students enact movement, teachers take disciplinary action to get them back to their seats or some other stationary position instead of incorporating movement as a part of the lesson. Teachers demand "classroom voices," focused time-on-task, and traditional styles of interacting in lieu of excitement and liveliness that is often accompanied by loudness and socializing. Instead of encouraging students to value what benefits groups over individuals, teachers taut and enforce individuality. Such instances of opposition can be reduced in occurrences and in intensity when the culture students bring with them is first viewed as cultural capital, i.e., valued currency to be used in development; culturally congruent science instruction achieves this goal and facilitates cultural border crossing into school science. (p. 195)

3.3.2 | Family

Lastly, in addition to the strong role of teachers, family members are also key influencers in the early STEM participation of Black youth. King (2013) and Robinson et al. (2016) found that parental socioeconomic status was a strong predictor of a student's high school mathematics proficiency. According to King (2013), this correlation can be attributed to parents' higher ability to invest in more physical capital such as books, computers, and other supplemental STEM enrichment resources. However, most other researchers attributed the high correlation between positive STEM aspirations and achievement to interpersonal factors. Many researchers found that when parents pushed students to do well, gave praise about their abilities, and encouraged participation in STEM-related activities students were more likely to identify as scientists and develop an early interest in participation (Cornick, 2012; Jones, 2007; Showers, 2015). Jones (2007) also found that in some cases, students were motivated to choose a science career due to family health concerns.

4 | RECOMMENDATIONS

As a reminder, the research question guiding this inquiry is: *According to scholarly literature, what contextual factors most significantly influence the experiences Black children have with STEM?* While a great variety of issues are responsible for the underrepresentation of Black Americans in engineering, some common themes emerged among the implications and recommendations suggested by authors studying Black children's experiences with STEM. Cornick (2012) and King (2013) call for STEM-based programming to be introduced at an early age. Of the 41 studies included in this

review, only three had population samples of students below the fifth grade, with a majority of them focused on high school, then middle school student populations. This limited study of students in elementary school indicates a need to study issues of participation at earlier critical points in development. Another recommendation based on this body of the literature indicates the need for cultural relevance to be further incorporated into STEM education. Several researchers maintained that STEM programming would be better if it contained culturally relevant/congruent pedagogy (Andersen & Ward, 2014; Carr, 2015; Moses-Snipes & Snipes, 2005; Olszewski-Kubilius et al., 2017; Parsons et al., 2005). Interestingly, this suggestion appeared to be concentrated in academic resources devoted to Black American issues, such as the *Negro Educational Review*.

The findings from this synthesis also point to opportunities to use a wider range of methodologies to study the experiences of K–12 Black American students. While most articles on this topic were quantitative, researchers who study the issues of participation in STEM at the K–12 level from a qualitative standpoint believe that there is great validity in understanding the stories and experiences of students from their own accounts rather than simply relying on quantitative assessment data (Carr, 2015; Polman & Miller, 2010; Sato, 2013). As an example, Carr (2015) highlighted the need for exploring this topic from a qualitative perspective through the following statement: “understanding the behaviors, experiences, and feeling of humans cannot be studied using the same approach to quantitative empirical research used to study the reliability of a transistor” (p. 10). He further went on to assert that while engineers have the ability to reverse engineer problems involving human interactions in ways that educators and social scientists cannot, their efforts are “often truncated by rigid quantitative approaches to finding the solution to problems” (Carr, 2015, p.10).

Given the wide variety of topics covered in these studies, there were additional recommendations that were notable but difficult to categorize. These recommendations include the following: (1) Investigating the extent to which minority and low socioeconomic students achieve the learning outcomes associated with the engineering curriculum, in comparison to their peers who have had different learning opportunities. (2) Addressing the learning needs of students who have had limited engineering exposure and scaffold all students to achieve equally well across student subgroups when developing engineering curricula (Tolbert & Douglas, 2016). (3) Developing more Black American teachers to serve as STEM role models (Cornick, 2012; Showers, 2015). (4) Better equipping all teachers, regardless of race, to better support students following STEM paths (Fries-Britt et al., 2012). (5) Including student voice and perspective in research and efforts regarding their STEM participation (Lattimore, 2005; Sato, 2013). We encourage the engineering education community to take up these charges.

5 | CONCLUSIONS

As evidenced by the variety of findings of this literature review, the current deficit of Black Americans pursuing undergraduate degrees in engineering can be attributed to a variety of factors. In this study, we identified themes related to the factors associated with early STEM experiences that influence students' interest and further exploration. These themes were organized under three headings: (1) social, economic, and policy context; (2) STEM education and community context; and (3) local context. The first theme focused on issues of racism, sexism, and classism, while the findings associated with the second theme correspond to issues of social perceptions and access to STEM activities. Finally, the research findings corresponding to the last theme relate to educators and family in the learner's life.

What these findings reveal is an interlocking system of challenges associated with and opportunities for overcoming the preliminary “glass ceiling” that hangs over the heads of potential engineers from minority communities. Simply exposing students to scientists or engineers of the same gender or race will not suffice, and effective engagement must be present to ignite children's personal motivations. Additionally, STEM content and educational activities must be presented in ways that resonate with Black children on a cultural level, and account for the ways in which racism, sexism, and classism may significantly impede the educational opportunities of children in certain communities. To address these impediments, it is critical that the elements of the societal ecosystem that directly and indirectly influence our education system (policy, media, educational funding support, etc.) become better aligned in ways that make engineering and other STEM disciplines more interesting and culturally relevant. Left unaddressed, this reality will remain a never-ending cycle of low participation of Black Americans in engineering.

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APPENDIX

Article summaries

Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
A Hierarchical Linear Modeling Approach to Understanding the Role of Ethnicity and Socioeconomic Status on Precollege Engineering Conceptions Research to Practice	The purpose of this study is to examine the school and personal factors that are significant to elementary students' understanding prior to classroom experiences with engineering	When factoring in SES, how does that change our understanding of the ways we teach engineering to elementary students? ◦ What is the impact of SES on elementary students learning engineering? ◦ Do school characteristics, student ethnicity, and the sex of the student help explain student scores on the 15-item Engineering Knowledge Test given to second to fourth graders?	Sample size: 975; Gender: boys 497 (51%) and girls 478 (49%)	Numeric—post test
Academic Achievement and Career Choice in Science: Perceptions of African American Urban High School Students	The purpose of this qualitative study was to understand the influence of early mentoring, parental involvement, and ethnic identity on the achievement in science and career choice in science of African American 10th grade students	(1) The central question about achievement asked what the perception of African American urban high school students was about achievement in science. Additional sub-questions asked what factors influenced African American urban high school student achievement in science. (2) The central question about career choice asked what the perception was of African American urban high school students about a career in science. Sub-questions asked what factors influenced the decision of African American urban high school students to pursue careers in science-related fields and what obstacles African American urban high school students felt guided their career choices in science. (3) There were two central questions about environmental influences. What is the relationship between early mentoring, parental involvement, and ethnic identity on African American urban high school student achievement in science and career choice in science? What influence do early mentoring, parental involvement, and ethnic identity have on African American urban high school student achievement in science?	Sample size: 20; Gender: 11 (55%) were female and 9 (45%) were male	Text-interview and focus group discussion
Achievement emotions as predictors of high school science success among African-American and European American students	The objective of this study was to test the control-value theory that relates achievement emotions to academic achievement, to determine if race moderates the predictability of achievement emotions on outcomes on the GHSGT, science component, for African American students when compared to European American students	Do positive and negative achievement emotions, as measured by the AEQ, account for variance in science achievement scores on the GHSGT when controlling for reading ability, demographic make-up of the school, SES, gender, race, and teacher qualification data?	Sample size: 160; Gender: M = 80, F = 80; Race: African American = 80, European American = 80	Numeric-survey

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Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
African American Adolescent Female Identification with Engineering and Participation in Engineering Education	The purpose of this study was to understand high school African American adolescent females' identification with engineering and participation in engineering education	(1) In an urban high school, what are the factors that encourage and discourage African American adolescent females' identification with engineering? (2) How does African American adolescent females' identification with engineering influence their participation in engineering education?	Sample size: 4; Gender: all female; Race: All African American	Text-interviews, observations, and semi-structured focus groups
African American students' perceptions of their preparation for a high-stakes mathematics test	The purpose of this study is to understand six African American students' perspectives of their preparation for a high-stakes examination in mathematics in an inner-city high school	(a) How are students prepared for the mathematics portion of a high-stakes test? and (b) What do students suggest to improve the process?	Sample size: 6; Race: African American	Text-interview, observation
African-American Middle School Girls: Influences on Attitudes toward Computer Science	The research reported in this article helps cover this gap and can play a role in gaining insight into the attitudes of African-American middle school girls toward the field of computer science	Missing	Sample size: 37; Gender: all females; Race: 81.1% were African-American, 2.7% were Native American, 2.7% were Asian, and 13.5% were of multiple ethnicities	Both: Numeric-questionnaire, survey, scales; Text-focus groups
An Examination of the Association between Demographic and Educational Factors and African American Achievement in Science	The purpose of this research study was to investigate whether an association existed among the teacher's demographic factors (years of teaching experience and gender), educational factors (certification type and certification pathway) and the percent passing rate of tenth grade African American male students on the 2010 science TAKS	(1) Is there an association between the teacher's demographic factors (years of teaching experience and gender) and the percent passing rate of their tenth grade African American male students on the 2010 science TAKS? (2) Is there an association between the teacher's educational factors (certification type and certification pathway) and the percent passing rate of their tenth grade African American male students on the 2010 science TAKS? (3) Is there an association among the teacher's demographic factors, educational factors, and the percent passing rate of their tenth grade African American male students on the 2010 science TAKS?	Sample size: 96; Gender: 51 (53.1%) female and 45 (46.9%) male	Numeric-dataset
Are Black Girls the New Number Runners? An Analysis of Black Girls and High School Mathematics	The aim of this dissertation is to examine individual-level, familial-level, and school-level variables that impact Black female students' proficiency in high school mathematics as well as predict their enrollment in postsecondary math courses	Missing	Black females	Numeric-dataset
Changing Stories: Trajectories of Identification among African American Youth in a Science Outreach Apprenticeship	This article reports on a descriptive study of youth identity as developing through "trajectories of identification" in a science outreach apprenticeship program designed to transition urban African American youth to professional work and career asp... we aim to (1) clarify the challenges for educational programs that seek to encourage positive identity development toward professional careers among historically disadvantaged youth and (2) describe the promise and pitfalls encountered by participants in a specific program (the Youth Science program mentioned above) that works with primarily African American youth in a Midwestern urban context. Youth	Missing	Sample size: Missing African American teens	Text-case study-observation, focus interview, focus groups, artifacts

Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
Characteristics of Female Students Who Aspire to Science and Engineering or Homemaking Occupations	This study identified predictors that discriminated between nontraditional and traditional career aspirations in a sample composed of 930 eighth-grade female students	(1) Which independent variables in the National Educational Longitudinal Study of 1988 (NELS:88) best discriminate between girls who aspire to homemaking occupations and girls who aspire to science and engineering occupations? (2) Do certain variables have differential predictive power for girls from different racial-ethnic groups?	Sample size: 930; Gender: 100% female, Race: 52 Asian Americans, 123 Hispanics, 61 African Americans, 669 Whites, and 15 Native Americans	Numerical dataset
Classroom-Based Inequalities and Achievement Gaps in First Grade: The Role of Classroom Context and Access to Qualified and Effective Teachers	This study examined the degree to which three potential sources of classroom-based inequality contribute to reading and math achievement gaps that develop during first grade, including classroom context, access to qualified teachers, and access to an effective teacher	(1) What are the magnitudes of the underrepresented minority (URM) achievement gaps in reading and math at the beginning of first grade, and to what degree do they change during first grade? (2) Do student inputs vary across classrooms and schools? If so, to what degree do those differences account for school-based achievement gaps that accrue during first grade? (3) What are the magnitudes of school-based achievement gaps that develop during first grade? (4) Do the URM children have equitable access to: (a) classrooms with contextual characteristics conducive to learning, (b) highly qualified teachers, and (c) effective teachers? If not, to what degree does each contribute to the achievement gaps that accumulate during first grade?	Sample size: 3496; First grade students	Numeric-dataset and survey
Closing the Stem Gap with Culturally and Cognitively Appropriate Cyber-Instruction in an All-Girl Inner-City Charter School Stem Program: A Case Study	The purpose of this dissertation is to offer a different approach that addresses two of America's most pressing issues: The STEM crisis and the achievement gap. Engineers have a unique ability to synthesize and solve problems that educational and social scientists find too difficult or complex to address (Borrego et al., 2009)	The college mathematics courses that they took on campus the following semester	Sample size: 122; Gender and race: All are females (African Americans)	Both: Numeric-survey, scale scores; Text-interview
Effects of Design-Based Science Instruction on Science Problem-Solving Competency among Different Groups of High-School Traditional Chemistry Students	The purpose of this study was to investigate whether DBS affects student problem-solving competency and chemistry achievement across student demographics (gender, race, and SES)	(1) Does DBS have any effect on the problem-solving competencies of students in a high school traditional chemistry class? (2) Does the effect of DBS on problem-solving competency depend on gender? (3) Does the effect of DBS on problem-solving competency depend on race? (4) Does the effect of DBS on problem-solving competency depend on SES? (5) Does DBS have any effect on the chemistry achievement of students in a high school traditional chemistry class? (6) Does the effect of DBS on chemistry achievement vary depending on gender? (7) Does the effect of DBS on chemistry achievement vary depending on race? (8) Does the effect of DBS on chemistry achievement vary depending on SES? (9) Is the problem-solving competency of students in a traditional chemistry class predictive of their chemistry achievement?	Sample size: 82; Gender: M = 43, F = 39; Race: Asians—2; Black—40; Hispanic—34; Native American—3; White—3	Numeric-quasi-experiment, pre-post test

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Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
Examining How Youth of Color Engage Youth Participatory Action Research to Interrogate Racism in Their Science Experiences	The purpose of this study was to investigate how making race and racism explicit can be empowering for youth to understand their own experiences and challenge the way science learning can pose barriers to potential career trajectories	(1) How do youth of color talk about their experience with school science? (2) How does racism in high school affect STEM trajectories? (3) How do youth engage youth participatory action research to navigate barriers to STEM trajectories?	Sample size: 5; Race: All African American; Gender: M = 2, F = 3	Text-Ethnography: Observation and field notes, group discussions, interviews, artifacts
Examining the Characteristics of High Schools in Which Black Students Achieve in Mathematics	The purpose of this study is to examine the characteristics of high schools that exert a positive influence on the mathematics achievement of Black students on 12th-grade mathematics tests	(1) How do mathematics achievement in 12th grade for Black high school students vary, both across and within schools? School Level School Factors (Principal Influence; Principals' Perceptions of School Safety; and School Segregation) Department Factors (Department Size; Collective Responsibility for Learning; and Variability in CRL) Student-Level Teacher Factors (Teaching Practices/Active Math Learning; Teaching Experience; and Teacher's Highest Degree) Student Background Variables (Tenth Grade Mathematics Achievement; Gender; SES; and Students' Perceptions of School Safety)? (2) How do student factors (i.e., 10th grade mathematics achievement, gender, SES, and students' perceptions of school safety); teacher factors (i.e., teaching practices, teaching experience, teacher's highest degree), and the student-level interactions (gender and SES, gender and prior math, SES and practices) impact Black students' 12th grade mathematics achievement in high school? (3) How do department factors (i.e., department size and collective responsibility for learning); school factors (i.e., principal's influence, principals' perceptions of school safety, and school segregation); and the cross-level interactions impact Black students' 12th grade mathematics achievement in high school?	Sample size: 1607; Gender: 52.2% of the Black students were female, 47.8% were male students	Numeric-dataset/survey
Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability students	In this study, models for the persistence plans of three groups of ninth-grade, high-ability students were developed and compared	(1) Each of the two measures of individuals' expectations for success in STEM, mathematics and science self-efficacy, will be significantly and positively related to persistence plans after controlling for SES, gender, and mathematics achievement. (2) Each of the five measures of subjective task value—STEM utility value, mathematics and science intrinsic values, and mathematics and science attainment values—will be significantly and positively associated with persistence plans after controlling for SES, gender, and mathematics achievement. (3) A positive perception of the cost of taking mathematics and science courses will be significantly and positively associated with persistence plans after controlling for SES, gender, and mathematics achievement	Sample size: 1757; Ethnicity: (13.8% Black, 26.7% Hispanic, and 59.6% White); Gender: 48.5% were female and 59.6% were male	Numeric-dataset

Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
Experimental and Credentialing Capital: An Adaptable Framework for Facilitating Science Outreach for Underrepresented Youth	In this case study, sports biomechanics was utilized as the area of shared interest, and understanding the slam dunk was used as experimental capital	Missing	Sample size: 50; Race: African American youths (85%); The rest of the youths were Caucasian (15%); Gender: male (75%), female (25%)	Text-experiment, poster
Glitch Game Testers: The Design and Study of a Learning Environment for Computational Production with Young African American Males	The research presented in this dissertation discusses the formative research that shaped the design of Glitch, the evaluation of the implementation of Glitch, and a theoretical investigation of the way in which participants navigated conflicting motivations in learning environments	How do different cultural values and technology practices impact participation in the production of computation?	Sample size: 25; Gender and race: Black males	Both: Text-observations and interviews; Numeric-surveys
In Their Own Voices: Exploring the Persistence of High-Achieving African American High School Students in Mathematics Leading to STEM Careers	The purpose of this narrative study was to explore stories of persistence told by five successful African American students enrolled in rigorous mathematics courses at two STEM magnet high schools	(1) How do the stories of successful students at Washington High School and Jefferson High School portray support in persistence from significant others in their lives? (2) What strategies of persistence do successful students at Washington High School and Jefferson High School describe in their stories about personal experiences in rigorous mathematics courses?	Sample size: 5; Race: African American	Text-narrative study: focus group interviews; unobtrusive documents, including academic records; and teacher recommendations
K-12 teachers: Important bridges to success for African American students	This paper is one product of a larger qualitative project to study underrepresented minority students majoring in physics and other related science, technology, engineering, and mathematics (STEM) fields	Missing	Sample size: 82; Race: Black	Text-focus groups and interviews
Math and Science Attitudes and Achievement at the Intersection of Gender and Ethnicity	The current study addresses this gap in the literature by describing gender differences in math and science attitudes and achievement among 367 White, African American, Latino/Latina, and Asian American 10th grade students in neighborhood public high schools from a large northeastern city	Using these methods to examine the intersection of gender and ethnicity, we ask the question, how do gender differences in math and science attitudes vary across ethnic groups?	Sample size: 367	Numeric-self-reported data and survey
Mathematics Achievement and Its Relation to Career Aspirations of Eighth-Grade African American, Anglo, and Hispanic Girls	To examine differences in mathematics achievement and career aspirations and to examine the relationships among variables: SES, mother's and father's expectations, teacher's/counselor's advice, math achievement, and girls' career aspirations	(1) Are there significant differences between mathematics achievement and career aspirations of different races? (2) What is the relationship between mathematics achievement and career aspirations of different races? (3) What is the relationship among parental expectations of a daughter's future career aspirations, SES, and girls' mathematics achievement?	Sample size: > 10,800; Gender: 100% girls	Numeric-cognitive test and questionnaire

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Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
<p>Minority Achievement Gaps in STEM</p>	<p>The current study examines the academic outcomes of the first stage of Project Excite (2000–2013)</p>	<p>Research Question 1: How did Project Excite students perform in math, science, reading, and English achievement tests compared with their peers from their local school districts or state? Research Question 2: Over the course of the program, from Grades 3 through 8, were there identifiable patterns of marked growth, plateaus, and/or declines in their performances? Research Question 3: Were project participants more likely to be placed in advanced above-grade-level math courses (i.e., gifted programs) than their peers in ninth grade? Research Question 4: Did participants continue to thrive through high school and launch a college career after high school graduation?</p>	<p>–</p>	<p>Numeric-experiment-like comparison on tests: Standards Achievement Test, the Explore test, the Measures of Academic Progress, and on rates of placement</p>
<p>Motivation and Academic Help-Seeking in High School Computer Science</p>	<p>The primary objective of this study was to determine the degree to which academic motivation predicted the executive help-seeking, instrumental help-seeking, perceived benefits of help-seeking, and avoidance of help-seeking of high school students enrolled in computer science (n¹/₄ 314)</p>	<p>–</p>	<p>Sample size: 314, Gender: (250 boys, 64 girls), Race: White students (n¹/₄ 142), African American students (n¹/₄ 82), and Asian American students (n¹/₄ 62) were represented.</p>	<p>Numeric-scale</p>
<p>Perceived Barriers to Higher Education in Science, Technology, Engineering, and Mathematics</p>	<p>Given the structural barriers in educational access and opportunity and the social/psychological barriers facing underrepresented students of color, this study utilizes frameworks of stress, coping, and stigmatization within a sample of 152 high-performing high school students of color to (a) Examine students' perceptions of internal and external barriers to STEM higher education, (b) Address the intersectionality of race and gender by assessing whether perceptions of barriers vary by race and gender, (c) Explore relationships between perceived barriers and STEM aspirations, and (d) Examine coping mechanisms to overcome perceived barriers to STEM degrees. Survey and focus group results revealed that despite academic ability, students perceived high levels of internal and external barriers to pursuing STEM studies in higher education</p>	<p>(1) To what extent do high-achieving students of color perceive internal and external barriers to pursuing STEM in higher education? (2) Do perceived internal and external barriers vary by demographic variables? (3) What is the relationship between perceived internal and external barriers and STEM career aspirations? (4) To what extent do participants demonstrate confidence in overcoming barriers, and what coping responses are employed in response to perceived barriers?</p>	<p>Sample size: 152; Race: Latino (46%), African American (25%), and Vietnamese (9%), with other Southeast Asian and multiracial students comprising the remaining 20%; Gender = 49% of scholars being female</p>	<p>Both: Numeric-pre-post survey and Text-focus group</p>
<p>Perceived Factors that Influence Career Decision Self-efficacy and Engineering Related Goal Intentions of African American High School Students</p>	<p>This study's aim was to gain insight into career decision making among African American high school students as it relates to the field of engineering</p>	<p>Research Question 1: To what extent do exogenous factors (school, math/science interest, ethnic identity, math/science confidence, family relations) and endogenous factors (demographic and ability) influence career decision self-efficacy? Research Question 2: To what extent do exogenous factors (school, math/science interest, ethnic identity, math/science confidence, family relations) and endogenous factors (demographic and ability) influence math/science related goal intentions?</p>	<p>Sample size: 396; Race: All African American; Gender: 182 males (46%) and 214 females (54%)</p>	<p>Numeric-survey</p>

Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
Predicting High School Students' Interest in Majoring in a STEM Field: Insight into High School Students' Postsecondary Plans	This study examined how various individual-, family-, and school-level contextual factors impact the likelihood of planning to major in one of the science, technology, engineering, or mathematics (STEM) fields for high school students	How do individual-level factors as well as family- and school-level contextual factors help determine the extent to which high school students plan to major in a STEM field?	Sample size: 27,935	Numeric-dataset
Promotive and Corrosive Factors in African American Students' Math Beliefs and Achievement	This study examines the role of "relevant math instruction," or math teachers' emphasis upon making lessons interesting and the usefulness of math for students' everyday life. 2002). Specifically, this study examines the roles of relevant math instruction and school racial climate in self-concept of math ability, math task value, and math achievement among African American students	–	Sample size: 618; Race: African American	Numeric-dataset
Representing Racial Identity, Race, the Construction of the African American STEM Students	This content analysis study documented an urban school's attempt to use representational practices to promote positive science identities for African American boys	Research Question 1: How does an urban charter school for African American males attempt to define the students' identity? Research Question 2: How do the representational practices of the school reflect the school's overall mission? Method	N/A	Text-signs within schools
Saving Face While Geeking Out: Video Game Testing as a Justification for Learning Computer Science	In this article, we explore the use and design implications of face-saving tactics these young men used to "geek out" on computer programming, choose computer science for their career, and maintain their current identities with friends and families	–	Sample size: 32 Race: 100% African American; Gender: 100% male	Numeric-survey
The Black cultural ethos, students' instructional context preferences, and student achievement: An examination of culturally congruent science instruction in the eighth-grade classes of one African American and one Euro-American teacher	With regard to "science for all," this study addressed the NSES oversight by investigating achievement with respect to culturally congruent science instruction. More specifically, the study examined achievement with respect to the Black cultural ethos (BCE)	–	Sample size: 40; Race: African American and Whites	Both: Text-case study (classroom observation and field notes, interview); Numeric-pre-post test, dataset
The call: The importance of research on African American issues in mathematics and science education	Purpose of this study is to (1) report on an in-depth case study of a former state mathematics consultant to describe his experiences of the mathematics education of African Americans in public high schools in North Carolina from 1950–1980 and (2) to examine North Carolina African American students' progress in mathematics from the Brown vs. the Board of Education Decision to the No Child Left Behind Act Era	(1) What was the mathematics education experience of African Americans in public high schools in North Carolina from 1950 to 1980? (2) From the Brown v Board of Education decision to the No Child Left Behind Act, what progress have North Carolina African American students made in mathematics?	Sample size: 1; Race: White; Gender: male	Text-interview

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Article title	Purpose/aim/goal	Research question	Participant demographics details	Methods—Data type
The Effect of the Advanced Placement Training and Incentive Program on Increasing Enrollment and Performance on Advanced Placement Science Exams	The purpose of this study is to examine the effectiveness of the National Math and Science Initiative's Advanced Placement Training and Incentive Program (APTIP) on the number of students taking advanced placement (AP) science courses and their performance	(1) Does participation in the National Math and Science Initiative (NMSI) Advanced Placement Training and Incentive Program (APTIP) increase Advanced Placement science exam takers? (2) Does participation in the NMSI APTIP program increase performance (scores of 3, 4, or 5) of students on AP science exams? (3) Are more females enrolled and African American students taking AP science exams courses in schools that participate in the NMSI APTIP program than prior to the intervention? compared to the state and national trends for the same subgroups? (4) Are females and African American students experiencing increased performance on AP science exams in schools that participate in the NMSI APTIP program compared with performance before the intervention? The state and national trends for the same sub-groups of students?	39 schools (no additional details provided)	Numeric-dataset
The Examination of a Pullout STEM Program for Urban Upper Elementary Students	The purpose of this study is to determine whether a pullout STEM program makes reading and math scores decrease and examine its impact on urban fourth-, fifth-, and sixth-grade students' attitudes and perceptions regarding STEM education and careers	(1) How do the state-standardized test scores for STARBASE students compare to students' scores from other school divisions in region? (2) In what ways does STARBASE impact student interest and attitudes toward STEM content and careers?	Sample size: 11,668	Numeric-dataset
The Psychosocial Factors Contributing to the Underrepresentation of African American Males in Advanced High School Mathematics Courses	The purpose of this qualitative study was twofold: (1) to determine the perceptions of African American males on the psychosocial factors and pedagogical strategies that result in the underrepresentation of African American males in advanced math courses, and (2) to provide insight into how their perceptions can help inform best practices for the recruitment and retention of African American males in advanced math courses	(1) What do African American males identify as psychosocial factors contributing to their underrepresentation in advanced math courses? (2) What pedagogical strategies are identified by African American males as more conducive to their learning mathematics? (3) What are African American males' perceptions on how both psychosocial factors and teaching strategies affect their motivation to enroll in advanced math courses?	Sample size: 6	Observation
Understanding Black Male Mathematics High Achievers from the Inside out: Internal Risk and Protective Factors in High School	The purpose of the present paper is to offer an account of the internal risk and protective factors that influence the racial, gender, and academic trajectories of the same group of mathematically high-achieving Black males during their next transitional stage: high school	(1) How does mathematics identity develop during high school years of mathematically high-achieving African American males? (2) What are the internal risk and protective factors that mediate high achievement in mathematics in particular and academic achievement in general during this time period?	Sample size: 13; Race: 100% Black; Gender: 100% male	Text-interviews
Understanding the Attitudes of African American Middle School Girls toward Computer Science	The research presented in this paper used a mixed methods approach to understand the attitudes of African American middle school girls toward computer science and investigated the factors that influence these attitudes	Missing	Sample size: 5; 81.1% were African American, 2.7% were Native American, 2.7% were Asian, and 13.5% were of multiple ethnicities	Numeric-survey and text-focus groups