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Keywords

engineering identity, elementary students, informal learning, case study

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Enhancing Engineering Identity Among Boys of Color

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Abstract

Black and Brown men continue to be underrepresented in engineering. One explanation for the dearth of Black and Latino men in engineering is that engineering (and STEM) identity often is not inclusive of People of Color. As a result, Black and Brown boys may be less likely to become interested in STEM subjects. The purpose of this study, then, was to investigate how the components of one afterschool engineering program tap into engineering identity formation among fourth- and fifth-grade Black and Brown boys. Leveraging research on the STEM and engineering identity, we argue that the program and its key components play both constructive and protective roles. This study comprises a case study of an afterschool engineering program completing its third year of implementation at three elementary schools. Over four semesters, we recruited approximately 60 students from the three schools and 21 mentors to participate in the study. We collected data via one-on-one interviews, focus groups, and observations. We found that engineering design activities are constructive, offering the young Black and Brown boys opportunities to engage with the work of engineers. The mentors played constructive roles by recognizing the students' engineering work. The mentors also played a protective role, buffering against identity interference and cultivating a sense of belonging. We conclude by discussing how the findings contribute to existing research on engineering identity and making recommendations for practice.

Keywords: engineering identity, elementary students, informal learning, case study

Introduction

People of Color, specifically Black and Latino/Brown men, continue to be underrepresented in many science, technology, engineering, and math (STEM) fields (Funk & Parker, 2018; Roy, 2018). Indeed, among engineering undergraduates nationally, only 2.7% and 7.8% of all engineering bachelor's degrees in the USA in 2018 were awarded to Black and Latino men, respectively (Roy, 2018). One explanation for the dearth of Black and Latino men in engineering is that engineering (and STEM) identity often is not inclusive of People of Color (Malone & Barabino, 2009; McGee, 2016; McGee & Martin, 2011; Ortiz et al., 2020). Students from minoritized racial and ethnic communities may be less likely to identify with an area of study and profession that are perceived as (Archer, 2008) and continue to be mostly male and White (Atwater, 2000; Bodzin & Gehringer, 2001; Braden, 2020; Calabrese Barton & Tan, 2010; Collins, 2018; Moore III et al., 2003; Starr, 2018; Tan & Calabrese Barton, 2010), and hostile to People of Color (McGee, 2016, 2020; Seymour & Hewitt, 1997).

Afterschool STEM Learning

One way researchers and practitioners have sought to make STEM spaces more inclusive and enhance Students of Color's beliefs about STEM is through informal learning opportunities such as afterschool programs. Afterschool STEM programs can be innovative environments for exploration and engagement (Moreno et al., 2016). Students benefit from the smaller group sizes, greater instructional flexibility (Dabney et al., 2012), and the lower stakes that afterschool programs often offer (Maltese & Tai, 2010). Importantly, afterschool programs can allow students to engage with STEM on their terms, redefining what it means to do STEM and be a STEM person (Calabrese Barton & Tan, 2010; Calabrese Barton et al., 2013; Gonsalves et al., 2013; Ryu et al., 2019; Yu et al., 2021). Recent research suggests that participating students can improve their STEM knowledge as well as their STEM interest (Dabney et al., 2012; Maltese & Tai, 2010) and help develop their STEM identity (Allen et al., 2019; Calabrese Barton et al., 2013; Gonsalves et al., 2013; Ryu et al., 2019; Yu et al., 2021). However, we know less about how afterschool programs cultivate STEM identity among elementary-aged students.

The purpose of this study, then, was to investigate how the components of one afterschool engineering program tap into engineering identity formation among fourth- and fifth-grade Black and Brown boys. The following research question guided our study: *How do the critical components of an afterschool engineering program connect to engineering identity among elementary-aged Black and Brown boys?* We leverage recent research syntheses on STEM (Radovic et al., 2018; Simpson & Bouhafa, 2020) and engineering identity (Patrick & Borrego, 2016; Rodriguez et al., 2018) to argue that the program and its key components play both constructive and protective roles.

Theoretical and Empirical Foundations

In this section, we describe the theoretical and empirical foundations for our study. We begin by defining STEM and engineering identities. Then, we describe three barriers to STEM identity formation among Students of Color. After that, we highlight how STEM and engineering identities form, focusing on identity formation among historically marginalized students. Finally, we offer the conceptual framework that we used to guide our work.

STEM Identity

Scholars have defined STEM identity[1] in multiple ways. For example, Brickhouse (2001) defines science identity as "the sense of who students are, what they believe they are capable of, and what they want to do and become in regard to science" (as cited in Aschbacher et al., 2010, p. 566). Carlone and Johnson (2007) describe science identity as the convergence of three components: competence, performance, and recognition. Competence refers to the belief that one is good at a task. Performance refers to the evidence that one is good at a task. Recognition refers to both the external and internal acknowledgment of one's competence and belonging. Collins (2018) proposes a framework for understanding STEM identity among Black students specifically, arguing that there are four dimensions: reflective identity (sense of belonging), competence or ability, value or interest (which reflects the intersection of what students believe is essential and what society values), and assimilation (what students must do to be successful in STEM; Collins, 2018).

The authors of two recent reviews of STEM identity research tried to make sense of the different definitions by categorizing them into three dimensions (Radovic et al., 2018; Simpson & Bouhafa, 2020). The first dimension is subjective/social, which refers to how one sees oneself in relation to STEM and how identity is constituted through STEM-related social discourse and practice. In this light, STEM identity is how one perceives oneself in relation to STEM and the extent to which others recognize that STEM identity. The second dimension, representational/enacted, refers to how identity is constituted through "narratives or stories about one-self" (Radovic et al., 2018, p. 26) or through the ways one engages or participates in STEM. In other words, the second dimension defines identity through how one talks about oneself and how one performs roles related to STEM. The third and final dimension is how identity changes over time or the malleability of identity.

Engineering Identity

Engineering education researchers have drawn on the STEM identity literature to define engineering identity, and thus conceptualizations of engineering identity vary across studies (Morelock, 2017; Patrick & Borrego, 2016; Rodriguez et al., 2018). Existing definitions tap into the subjective/social and representational/enacted dimensions, though all also assume that engineering identity is malleable and can be cultivated. For example, Tonso (2006a) proposes three dimensions that

[1] We refer to identities that relate to science, technology, engineering, or math as STEM. As such, we draw on literature from across the four areas.

overlap with the subjective/social and representational/enacted dimensions: thinking of oneself as an engineer (internal recognition), acting as an engineer (performance), and having others recognize one as an engineer (external recognition). In contrast, Capobianco's (2006) definition of emerging engineering identity sits primarily in the subjective/social dimension and what students think about themselves: academic (individuals' beliefs about themselves as students), institutional (individuals' beliefs about themselves relative to their programs, departments, courses, and universities), and intersectional (individuals' beliefs about themselves as women, Latinxs[2], etc., and how that interacts with engineering). More recently, Chu et al. (2019) offered yet another definition of engineering identity that combines the subjective/social dimension—external recognition—with interest in engineering, which derives from Eccles and colleagues' (1983) work on the value that people derive from completing a task (e.g., interest value).

Barriers to STEM Identity Formation Among Black and Brown Boys

Researchers have identified detractive factors (Morelock, 2017) that may limit the extent to which Black and Brown boys develop an internal recognition of a STEM identity. The first factor that may limit students' development of a STEM identity is identity interference. Identity interference assumes that we all have more than one identity and that sometimes one identity (e.g., gender or race) conflicts with the enactment of a second identity (e.g., science; Van Sell et al., 1981). As an example, Archer et al.'s (2014) work on masculinity in the UK points to identity interference when they suggest that boys' "performances of masculinity may facilitate or constrain their engagement with science and the extent to which science can be envisaged as a possible or desirable future career path and that this is patterned along class lines" (pp. 20–21). Similarly, scholars of Black male identity have noted that Black boys may adopt a "cool pose," defined as "a ritualized form of masculinity that entails behaviors, scripts, physical posturing, impression management, and carefully crafted performances that deliver a single, critical message: Pride, strength, and control" (Henfield, 2012, p. 181), when they sense that an activity or task conflicts with their existing identities (hooks, 2004). In her framework for Black STEM identity, Collins (2018) concurs with hooks (2004), positing that, "if assimilation within the STEM culture includes any perception of conflict to their core identity, students will again begin to question whether or not they belong" (p. 162).

A second factor that can detract from students' development of a STEM or engineering identity is the lack of a sense of belonging that historically marginalized students may experience. Engineering and other STEM disciplines can have very particular norms and cultures that often leave Students of Color feeling (and often *being*) marginalized and excluded (Collins, 2018; McGee, 2020; McGee & Martin, 2011; Tan & Calabrese Barton, 2016). For example, Grossman and Porche (2014) argue that microaggressions—the "brief, everyday exchanges that send denigrating messages to People of Color because they belong to a racial group" (Sue et al., 2007, p. 272)—can erode Students' of Color sense of belonging. Students of Color may experience these microaggressions because many STEM disciplines, and engineering in particular (Fox, 2006), are stereotyped as male and White or Asian; therefore, women (Du, 2006; Faulkner, 2007; Tonso, 1999) and Students of Color (Malone & Barabino, 2009; McGee, 2016; McGee & Martin, 2011; Ortiz et al., 2020) may not feel like they belong—or may be made to feel like they do not belong. Furthermore, STEM disciplines often position STEM knowledge as objective, colorblind, and apolitical, when in practice it prioritizes White ways of knowing, doing, and being, thus othering Communities of Color (Baber, 2015; Bang et al., 2012; Bullock, 2017; Calabrese Barton & Tan, 2010; McGee, 2020; Vakil & Ayers, 2019). Additionally, STEM subjects are often taught in a culturally irrelevant or unresponsive way for Students of Color (Bang et al., 2012, 2017; Bang & Medin, 2010; Collins, 2018; Mack et al., 2019; McGee, 2020). As a result, students may struggle to see how STEM knowledge and practices relate to their communities and their ways of being (Bang et al., 2017; Calabrese Barton & Tan, 2010; Calabrese Barton et al., 2013; Tan & Calabrese Barton, 2008, 2016).

Engineering Identity Formation

Researchers have identified multiple ways that students can develop an engineering identity. In his review of research on engineering identity, Morelock (2017) uncovered three factors that influence engineering identity formation: constructive factors, detractive factors, and directional factors. Constructive factors help students develop an engineering identity, detractive factors weaken or inhibit engineering identity formation, and directional factors shape the nature of the engineering identity that forms. Morelock (2017) categorizes constructive factors as engineering experiences, which expose students to engineering practices and knowledge, and engineering network, which is the accumulation of connections, such as peers, professionals, and role models.

[2] We use the term Latinx because, in Spanish, Latino refers to men and Latina to women and we seek to be inclusive of all genders.

In this study, we consider an afterschool STEM program as a set of constructive factors that can help develop the participating students' engineering identity and protect against barriers to engineering identity development. We use the program's key components—hands-on engineering design activities and STEM mentors (Manuel et al., 2018; Snodgrass Rangel et al., 2021)—as a starting point for understanding how the program can cultivate or enhance engineering identity in elementary-age Black and Brown boys through the provision of engineering experiences and an engineering network. For this reason, we focus here on three mechanisms: practicing or "doing" STEM, being exposed to STEM role models, and having a STEM mentor.

Doing Engineering

One way that researchers suggest that students form an engineering identity is the *doing* of STEM—through classes, afterschool activities, books they read, observations of parents or family members working, and other STEM-related experiences. Indeed, many scholars contend that students develop STEM identities by representing and enacting STEM-related roles in communities of practice: the *doing* of STEM in the form of hands-on and authentic activities (Adams & Gupta, 2013; Aschbacher et al., 2010; Major & Kirn, 2017; Olitsky, 2007; Packard & Nguyen, 2003; Radovic et al., 2018; Simpson & Bouhafa, 2020; Yoon et al., 2014) and the use of scientific language or discourse (Brown, 2004; Brown et al., 2005; Dou et al., 2019; Radovic et al., 2018; Ryu et al., 2019). Authentic activities such as afterschool programs (Calabrese Barton et al., 2013), service-learning (Dukhan et al., 2008), team projects and collaboration (McLean et al., 2020; Tonso, 2006a, 2006b), and open-ended design challenges (Baldwin et al., 2016; Chu et al., 2019; Lachapelle & Cunningham, 2017; Rohde et al., 2019) are examples of *doing* (enactment) that can cultivate relevant discourse (representation) (Allie et al., 2009; Brown et al., 2005; Ryu et al., 2019) and specialized cultural knowledge (Brown et al., 2005; Tonso, 2006a). Furthermore, authentic engineering activities can help cultivate an engineering identity's subjective/social dimension—as a narrative of oneself as an engineer (Calabrese Barton et al., 2013; Eliot & Turns, 2011; Radovic et al., 2018; Simpson & Bouhafa, 2020). Students' use of engineering-specific discourse and practices demonstrates how they can "try out" engineering identities by utilizing the vocabulary and practices that engineers use.

Role Models

A second way that students can develop an engineering identity is by having positive role models. Role models can act as constructive factors by mitigating the stereotype threat that marginalized groups often experience in settings where historically they have been excluded. Under some conditions, observing a role model similar to oneself with the same race and/or gender can lessen the negative impact of stereotype threat on performance. For example, a 2009 study examined the effect of President Obama as a role model for Black Americans, concluding that exposure to his nomination by the Democratic Party in 2008 and his election in 2009 diminished the effect of negative racial stereotypes on the verbal performance of a sample of Black American adults (Marx et al., 2009). Similarly, exposure to role model biographies that contradict STEM stereotypes positively affected the sense of belonging among undergraduates studying STEM areas and non-STEM areas and on the STEM students' academic self-efficacy (Shin et al., 2016). Finally, researchers studying elementary-aged Girls of Color participating in an informal engineering program found that the undergraduate engineering students who participated in the program served as role models. The students described how they connected with the role models, who helped the young students see engineering differently (McLean et al., 2020).

Mentors

A third and final constructive mechanism of identity development that we explore is mentoring. Mentoring is an increasingly common strategy to address the underrepresentation of White women, Black, and Latinx students (and people more generally) in STEM (Kupersmidt et al., 2018; National Academies of Science, Engineering, and Medicine, 2019). Mentoring can enhance mentee STEM identity in several ways. The first is making mentees feel like they belong as part of a community (Mondisa, 2018; Mondisa & McComb, 2015, 2018; Yu et al., 2021). Second, it may expose mentees to mentors who share the same racial or ethnic identity, which is particularly important for marginalized students who otherwise may not see people who look like them working in STEM fields (Alston et al., 2017; Mondisa, 2018; Rosenthal et al., 2013; Shin et al., 2016; Young et al., 2013). Moreover, though most research on mentors in elementary and secondary STEM has focused on women, general research on role models and mentoring (Saddler, 2010) as well as research on mentoring in postsecondary STEM settings (Alston et al., 2017) suggest these relationships hold for marginalized Black and Brown boys (National Academies of Science, Engineering, and Medicine, 2019). Finally, STEM mentors may enhance their mentees' STEM identity by helping the mentees see that a career path in STEM is feasible and that it is worth persisting through the many challenges they are likely to encounter (Mondisa, 2018).

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Summary and Gaps in the Literature

Researchers increasingly utilize identity as a construct to understand the continued marginalization of students in STEM more broadly (Simpson & Bouhafa, 2020) and in engineering specifically (Morelock, 2017; Patrick & Borrego, 2016; Rodriguez et al., 2018). Engineering identity formation is subject to factors that are constructive and cultivate it further, those that are detractive and inhibit its development, and those that shape its nature. As discussed above, researchers have identified at least two detractive factors or barriers to identity development: identity interference and a lack of a sense of belonging. Afterschool STEM programs, particularly those with a mentoring component, can be constructive and protective against detractive factors because they provide an opportunity to "do" engineering and engage with role models and mentors.

Our understanding of how young Black and Brown boys develop an engineering identity still has gaps. The first is that most existing STEM identity research and engineering identity research generally has explicitly focused principally on older students and, therefore, may be limited in its ability to explain engineering identity formation among younger, elementary school-aged children (Simpson & Bouhafa, 2020). Nevertheless, the elementary years are crucial for developing students' engineering identities, as interest in STEM areas tends to drop beginning in middle school (Hill et al., 2010; Maltese & Tai, 2011; Sadler et al., 2012). For this reason, we focus our work on elementary-aged students. A second gap is that relatively little research examines boys' participation in afterschool STEM programs and how those programs may cultivate their STEM or engineering identities. For very good reasons, many STEM enrichment programs and initiatives focus on girls; however, Boys of Color also are underrepresented in STEM majors (National Center for Education Statistics, 2019) and careers (National Science Foundation, 2020) relative to their White and Asian peers. For this reason, our program—and therefore our research—focuses on Black and Brown boys. Finally, a third gap in existing research is that few studies examine *how* afterschool programs can cultivate engineering identity among young Black and Brown boys. We seek to address this gap by drawing on recent research on STEM and engineering identity to demonstrate how the program's key components tap into engineering identity formation for the young boys.

Conceptual Framework: Connecting Program Components to Engineering Identity Formation

Our goal is to understand and articulate how designing and implementing an afterschool engineering program with a mentoring component can support engineering identity formation among Black and Brown boys. As depicted in Figure 1, we draw on recent research syntheses of STEM (Radovic et al., 2018; Simpson & Bouhafa, 2020) to define engineering identity—the outcome of interest—as having three dimensions: subjective/social, representational/enactment, and malleability. Then, we leverage Morelock's (2017) synthesis of engineering identity research to identify key program components that function as constructive factors that promote engineering identity development. In this way, we conceptually link identity to the factors that help enhance it. The two key program components we focus on are the

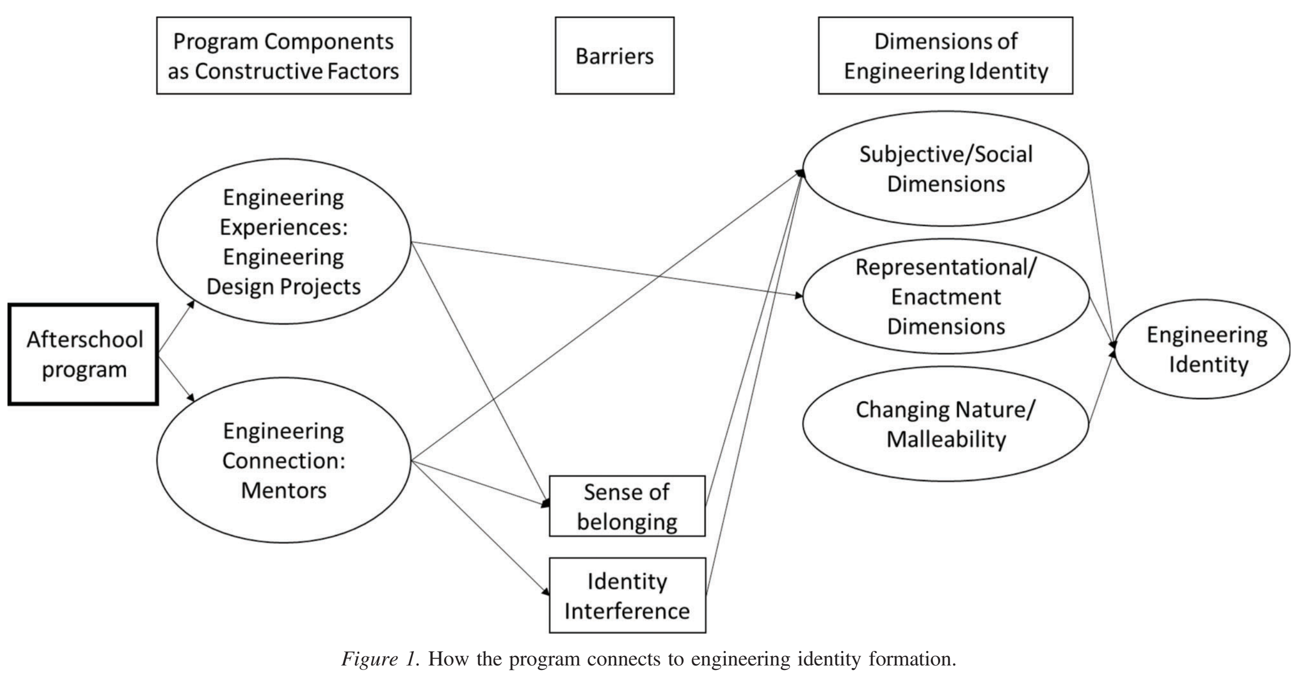

Figure 1. How the program connects to engineering identity formation.

engineering design projects as an example of engineering experiences and program mentors as providing engineering connections for the participating young students. We also include the two types of barriers that we described above: the lack of a sense of belonging that Students of Color experience in engineering environments and the way engineering identity may interfere with students' existing identities. We argue that the program components connect to the three dimensions of engineering identity in ways that are both constructive (enhancing identity formation) and protective (lowering barriers to identity formation).

Program Components as Constructive

We begin with the ways that the program components are constructive for all students. First, the engineering design projects provide opportunities for young students to "try on" being an engineer, that is, to develop the representational/enactment dimension of engineering identity. This "trying on" occurs through the doing of engineering work as students engage in engineering practices (Adams & Gupta, 2013; Aschbacher et al., 2010; Major & Kirn, 2017; Olitsky, 2007; Packard & Nguyen, 2003; Radovic et al., 2018; Simpson & Bouhafa, 2020; Yoon et al., 2014) and discourse (Allie et al., 2009; Brown, 2004; Brown et al., 2005; Dou et al., 2019; Radovic et al., 2018; Ryu et al., 2019; Tonso, 2006a). Second, the program mentors serve to cultivate the subjective/social dimension of engineering identity by recognizing the young students as engineers (Carlone & Johnson, 2007; Portsmore et al., 2019) and helping them see themselves as engineers.

Program Components as Protective

The program components also are protective against common barriers to engineering identity formation, which is important when working with historically marginalized students. The engineering design activities and the mentors help cultivate a sense of belonging among the young Black and Brown boys. In the same way that "doing" the work and speaking the language of engineers cultivates representational/enactment identity, it also makes them feel part of the engineering community of practice (Olitsky, 2007). The mentors also make the young students feel that they belong because the mentors can connect with the students on a personal level and many of them share racial and ethnic identities with the students. In other words, the mentors help the students feel comfortable and see themselves in the engineering community.

Both program components also help address identity interference in ways similar to how they engender a sense of belonging. The engineering design activities are designed to be engaging, have low stakes, and be relevant to the students. Because the activities are engaging and relevant, the students are more willing to participate in a meaningful and not transactional way. The meaningful participation and the joy that the students derive from the activities help them connect with the work. The low-stakes nature of the activities derives from the engineering design process itself as it assumes that students will test and refine their designs, i.e., they can make and correct mistakes (Hynes et al., 2011). The relevance of the activities also helps with identity interference by demonstrating that engineering work is for people like them. At the same time, the mentors, as role models, demonstrate that engineering is for people who look like them and who have shared interests. In other words, because the mentors can relate to the students personally—helping the students see themselves in the mentors—the young students are more likely to see that engineering is for them and people like themselves. In short, by making the young students feel like they belong in the engineering community, the activities and the mentors help lower the risk of identity interference.

Research Design and Methods

This study comprises a case study of an afterschool engineering program completing its third year of implementation at three elementary schools. A case study is an approach to inquiry in which the researcher examines one case—"a contemporary phenomenon within its real-life context" (Yin, 2002, p. 13)—with the goal of answering "how" and "why" questions about the case (Yin, 2002). As a design for the present inquiry, we consider our data as part of a single holistic design where the program is our single case or unit of analysis. One of the three schools has hosted the afterschool program since the spring of 2017, the second has hosted it since the fall of 2018, and the third was in its first semester of implementation in the fall of 2019, the last semester we consider here due to COVID-19's interruption of in-person learning.

Program Description

The afterschool STEM program was created in 2013 in a small city in Illinois to teach young Black and Latino boys engineering design through math and science content and to increase the boys' interest in STEM studies and careers through the mentoring relationship. Since the fall of 2016, the program has operated in a large metropolitan area in Texas, in the

Table 1
Demographics of school case sites from 2018–2019 academic year.

School	Type	Enrollment	Black	Latinx	White	Other	Economically disadvantaged	State accountability ratings
Jordan	Public	420	85%	14%	0.2%	1%	100%	C
Chavez	Public	490	2%	98%	0.8%	0.2%	95%	B
Charter	Charter	135	34%	43%	14%	8.9%	49%	D

Note. Data from the Texas Education Agency, Texas Academic Performance Reports, 2018–2019.

region's urban core. The afterschool program runs for eight weeks during both the fall and spring semesters, with sessions occurring three times a week—twice after school for an hour and a half and on Saturday mornings for two hours. The afterschool STEM mentoring program is designed to maximize the boys' exposure to STEM knowledge and careers. The mentors, who beginning in the spring of 2018 were paid, are required to attend the three sessions as well as a weekly mentor meeting.

In a typical weekday session, the mentors welcome the boys, have them sign in, and then sit at tables or grouped desks with the boys to help them with the math problem of the day. The mentors are assigned to one site per semester but are not assigned to specific mentees; whether they choose to work with a single group or multiple groups of students depends on the site and the nature of the interactions and relationships that organically develop. The typical ratio of participants to mentors is 5:1. After that, if it is a Tuesday, the mentors introduce the STEM professional of the week, who almost always is Black or Brown. The boys spend the bulk of their time across the three days working on the week's design challenge. On Tuesdays, they engage in an activity that allows them to explore the central topic (e.g., polymers). On Thursdays, the mentors present the students with the design challenge, and the students must design and test a solution. On Saturdays, they redesign and test their refined designs/solutions with the help of family members (Manuel et al., 2018).

Setting

Currently, the afterschool STEM program is being implemented in three elementary schools in the same large city in Texas. The schools have very different student populations (see Table 1) and have received different ratings on the state accountability ratings (Texas Education Agency, 2019). Two of the participating schools—Barbara Jordan Elementary School (Jordan) and Cesar Chavez Elementary School (Chavez)—are traditional public schools that are Title I schools. The charter school (Charter), which has participated in the afterschool program since the spring of 2017, is a university-affiliated K-5 public charter school.[3] Some students have parents who work at the affiliated university as faculty or staff, and so some, but not all, students at the charter school have high levels of exposure to STEM outside of the school setting. However, there also is a great deal of variability in student achievement within Charter across all grade levels and subjects: the average pass rate across all tests and grade levels in 2019 was 63% but was much lower for Black (47%), Latinx (61%), special education (11%), and economically disadvantaged (38%) students and was much higher for White (90%) students (Texas Education Agency, 2019). In contrast, Jordan and Chavez had higher average pass rates, 66% and 75%, respectively, with less variability across student groups.

Participants

We recruited our participants from the students and mentors who participated in the afterschool program during the last year and a half. Over four semesters, we recruited approximately 60 students and 20 mentors to participate in the study. Seven of the 20 mentors participated during more than one semester. As we describe in Table 2, four of the participating mentors identified as women, seven identified as Latinx, eleven as Black, one as White, and one as South Asian. One mentor participated as an alumnus of the university, while a second mentor was a graduate student. The remaining mentors were undergraduate students, all but two of whom were majoring in engineering.

The students who participated in the program and the study came from the three elementary schools described above. Over four semesters and across the three schools, approximately 60 students participated in the afterschool program and the study. According to program statistics from the 2018–2019 school year (the first year we report on here), 53% of students identified as Latino, 31% identified as Black, 4% identified as Asian, 4% as Black and Latino, and just under 7% identified either as more than one race, White and Latino, or White. Approximately 30% of the students in the program attend (or attended) Jordan ES, 40% attend Chavez ES, and 30% attend (or attended) Charter.

[3] The names of the schools are pseudonyms.

Table 2
Description of participating mentors.

Mentor	Participation	Gender	Race/ethnicity	Major
Audrey	Fall 2018	F	Black	Civil engineering
Jacob	Fall 2018–spring 2019	M	Black	Chemical engineering
Rafael	Fall 2018	M	Latino	Industrial engineering
Cassandra	Fall 2018–fall 2019	F	Black	Industrial engineering
David	Spring 2017, fall 2018	M	Black	Mechanical engineering
Jorge	Fall 2018–fall 2019	M	Latino	Mechanical engineering
Marcelo	Fall 2018–fall 2019	M	Latino	Mechanical engineering
Deepthi	Fall 2018	F	South Asian	Chemical engineering
Luis	Fall 2018–fall 2019	M	Latino	Mechanical engineering
Wesley	Fall 2018	M	Black	Computer engineering
Eric	Spring 2017, fall 2018	M	Black	Electrical engineering
Oliver	Spring 2018	M	Black	Math
Omar	Spring 2018	M	Black	Computer engineering technology
Robert	Spring 2018	M	White	Chemical engineering
Guillermo	Spring 2018	M	Latino	Mechanical engineering
Gary	Spring 2018	M	Black	Petroleum engineering
Ron	Spring 2019	M	Black	Mechanical engineering
Rosa	Fall 2019	F	Latina	Psychology
Yonatan	Fall 2019	M	Latino	Chemical engineering
Carter	Fall 2019	M	Black	Mechanical engineering

Table 3
Summary of data collection.

Data source	Frequency of collection	Duration
Mentor interviews	1 × semester	45–60 minutes
Student focus groups[a]	1 × semester	30–45 minutes
Student interviews[a]	1 × semester	30 minutes
Observations	2 weeks × semester: 6 sessions per semester	45–60 minutes

[a]In the first three semesters of the program, we interviewed the students in a focus group, but in the fourth semester, we interviewed them one-on-one.

Data Collection

In this section, we describe how we collected data for the study. We summarize all forms of data and the frequency with which we collected the data each semester in Table 3.

Interviews

At the end of each semester, we interviewed the mentors, including any returning mentors. The mentor interviews lasted between 30 and 60 minutes and were semi-structured (see Appendix B for the interview protocol). We interviewed five mentors in spring 2018, eleven mentors in fall 2018, six mentors in spring 2019, and five mentors in fall 2019. In the first three semesters we report on here, we interviewed all participating students in focus groups of five to seven students (approximately 40 students across the three semesters). However, in the fourth semester, we conducted one-on-one interviews with 18 students throughout the semester. Due to scheduling challenges, we interviewed the boys at the beginning of the semester at Charter, but at schools Chavez and Jordan, we interviewed them at the end of fall 2019. The focus groups lasted approximately 30–45 minutes, and the one-on-one student interviews lasted approximately 30 minutes. We audio-recorded all interviews and sent them out for professional transcription. Two authors collected the data and reviewed the transcripts for accuracy, making adjustments as necessary. When possible (i.e., one-to-one interviews), we use pseudonyms for our participants.

Observations

Finally, we observed two weeks of the program for six observations at each campus per semester. Observations lasted between 45 and 60 minutes, and we did not use a protocol. Instead, we spent 2–3 minutes with each mentor–mentee dyad or group and then rotated to a new dyad or group. We continued this rotation through the entirety of each observation with the goal of "sampling" multiple moments or interactions from each observation. We sought to be passive observers throughout the observations and did not ask the students questions about their work or designs. We did, however, try to document the explanations the students offered when the mentors asked them about their work. In the first two semesters, we took detailed field notes during our observations, including timestamps, who was engaged in the interaction, what they were doing, who was talking, and what they were saying. In the third and fourth semesters, we video-recorded six sessions (two weeks) at each school for a total of 18 video observations, following the same routine of spending 2–3 minutes with each mentor–mentee dyad or group and then rotating to a new dyad or group.

Data Analysis

Following Ryu and colleagues (2019), our analysis focused on the program as the unit of analysis. We began with our interview data and then analyzed our observation data.

Interview Data

One of the authors analyzed the interview data in two stages. First, we read the transcripts and coded them using *a priori* codes derived from the conceptual framework we describe above. We began by searching for examples of the two key program components—the engineering design projects and mentors—as constructive of identity. For example, we read for instances when the mentors or students referred to the activities they had completed or when the students talked about the mentors. Then, we considered the constructive nature of the program as it connected to two of the three dimensions of identity (representational/enactment and subjective/social). For example, we searched for instances when the students described their work during the activities or instances when the mentors spoke about the students as budding engineers. Finally, we read examples of the program components as protective against a lack of a sense of belonging and against identity interference. For example, we searched for instances when the students described how the mentors made them feel generally or about the engineering work specifically. Then, we coded the transcripts a second time, searching for emergent themes (see Appendix A for a list of all codes). These emergent themes were recurring and tended to relate to how the program activities and mentors enhanced the students' sense of belonging (e.g., through friendship) and mitigated identity interference (e.g., through shared interests). We conducted all coding using Atlas.ti software.

Observation Data

We utilized the observations to triangulate our interview data and understand how the activities and mentors were constructive and tapped into the representational/enactment and subjective/social dimensions of identity. First, we reviewed our field notes using several of the same codes to code our interviews (see Appendix A). Then, we viewed the videos using the codes to identify conversations and interactions that exemplified internal and external recognition. We recorded the observation data in an Excel spreadsheet to highlight critical moments from each session (e.g., mentor physical or verbal praise). Once we had coded and recorded those critical moments in the spreadsheet, we used that information to write summaries of the sessions, focusing on those moments, interactions, and conversations that demonstrated how the program cultivated either external or external recognition of the students' engineering identities. In these descriptions, we report only what we observed and inferred; we did not ask the students additional questions about their work as part of our observations. We selected two to include here.

Trustworthiness

Trustworthiness means that a study's findings are worth reporting (Lincoln & Guba, 1985). Throughout the study, we sought to enhance trustworthiness through triangulation and prolonged engagement in the field (Creswell & Miller, 2000). Triangulation is achieved when researchers search for and leverage agreement across more than one data source (Creswell & Miller, 2000; Denzin, 1978). In the present study, we triangulated across methods (i.e., interviews and observations). We also engaged with the afterschool program for a prolonged time (Fetterman, 2019). Here, we report on data collected in spring 2018 through fall 2019; however, the research team began attending and observing sessions and interviewing the mentors and mentees in 2017 when we piloted the afterschool program at Charter.

Position Statement

An important consideration with any research, but perhaps in particular with research about identity and marginalized identities, is the identities and positions of the researchers. Given the history of how researchers have portrayed marginalized communities and members of the Black community, researchers must examine their own identities, engage in reflection, and consider the context that the researcher and participants inhabit (Milner, 2007). One's positionality serves as a lens through which one sees and interprets the world. Therefore researchers must reflect on and disclose their position relative to their participants and relative to systems of oppression. Discussing positionality in the context of engineering education may be particularly important given the prevalence of post-positivist and colorblind approaches to research and knowing (Hampton et al., 2021; Mejia et al., 2018; Sochacka et al., 2018).

Though not meant to be a thorough reflection on our identities and positionalities, we do want to share something about ourselves and our relationship to the program we are studying. The first author is a Black male, an engineering professor, and the cofounder of the program. He helped start the program in 2013 in large part because he benefitted from Black mentors in engineering as a student. The second author is a White woman and an education professor. As a White woman and an outsider to the practice of engineering, she has worked closely with her team to identify and mitigate her biases. The third author also is a Black man and an engineering education professor. Though an insider to the experiences of Black men studying in engineering, he is an outsider to the program and relies on the team to check his understandings. The fourth author is a Black man and a cofounder of the program. As with the first author, he benefitted from strong mentors and sought to provide those experiences for young Black and Brown boys interested in engineering. Finally, the fifth author is a South Asian woman and a STEM education professor. Through her research, she is an insider to engineering education, but ethnically she is an outsider and relies on the team when considering findings and implications. Though the description of our team is brief, it demonstrates that our team is diverse, which is both a weakness and a strength. It means that we have multiple perspectives and experiences to draw from throughout the conduct of the research. However, it also means there is a mix of insiders and outsiders, which can affect everything from the program design to the interpretation of the findings. We have worked as a team to attend to our different experiences and positions continuously but recognize that this work is ongoing and imperfect.

Findings

The Program Components as Constructive

We begin by connecting the engineering design activities to identity as representational/ enactment. Specifically, the activities provided an opportunity for the young students to "try on" being an engineer through doing and discourse. As described above, each week, the students participate in different engineering design projects to learn about the engineering design process and apply mathematics and science content knowledge. The engineering design process comprises a cycle of iterative work in which engineers identify and seek to understand the problem, design a solution, test the solution, and revise the original design based on their test results (Daugherty & Custer, 2012). Similarly, the *Framework for K-12 Science Education* defines engineering design as "an iterative cycle of design" (National Research Council, 2012, pp. 201–202) and recommends using it in classrooms to apply science and solve problems. The National Research Council Framework identifies three key engineering design ideas: (1) define—defining and stating the problem to be solved; (2) develop solutions—designing and evaluating potential solutions to the problem; and (3) optimize—testing and refining solutions. Within the Next Generation Science Standards themselves, there is a performance expectation for grades three through five that states that students should devise multiple solutions to a problem, comparing them according to which best addresses the constraints and criteria of the problem (*Next Generation Science Standards*, 2013).

The engineering design activities offer the students an opportunity to "try on" being an engineer—the engineering identity—as they work on the activities and talk with each other and the mentors about the work and the materials. A goal of the activities also is for the students to handle the types of tools that engineers and scientists might use, from electrical wires in the circuit activities to droppers in the DNA activity and sodium polyacrylate, a polymer used in diapers because of its absorbency (it can absorb up to 300 times its mass in liquid), in a flood mitigation activity. As we observed each semester's sessions, we noted how the students handled the tools and increasingly used the technical terms they were exposed to as they spoke with one another and the mentors. Here, we briefly describe one example of how the students enacted engineering identity during the sessions. We provide some context for the activity and then describe some of the interactions that were representative of the session.

Identity as Representational/Enacted

The first activity we spotlight here is when the students learned about polymers. In the first lesson of the week, students learned that polymers are chains of repeating molecules and created a model using paper clips. In the second lesson, they learned that sodium polyacrylate is a polymer used in diapers because of its absorbency. Students dissected a diaper to observe the polymer and tested how much water a diaper can hold. In the culminating activity for the week, which occurred on a Saturday morning and was attended by the students' family members, students were challenged to use any of a series of materials, including diapers, to create a barrier model to protect their model town from flooding. The polymer activity has been implemented twice since 2017, and here we report on our observations from a Saturday session at Charter in spring 2018. During this session, we observed—and describe below—the students enacting engineering as they carried out the design process and used engineering vocabulary.

Defining the Problem. The students worked with their teams to understand the challenge and their options. The lead mentor, Marcelo, explained that the students had to build a model of a town, which then would be flooded with one cup of water; the challenge was to keep the town from being destroyed. When the mentors announced the challenge, family members nodded their heads in recognition—the region is prone to severe flooding during regular rainstorms—and the students began suggesting potential strategies. The mentors passed out the materials to create their towns (packing peanuts and a slanted plastic tray meant for interior house-painting). Marcelo then pointed to a table full of materials that the students could use to protect their model towns, such as popsicle sticks, pebbles, sand, tape, and diapers. The students were excited, their voices rising and falling as they began to discuss strategies given the materials. Each mentor sat down at a table and asked students which materials they were thinking about using and why.

Developing and Testing Solutions. The students designed solutions to protect their model towns from flooding, engaging in engineering discourse throughout the session. Amidst the excitement, the mentors focused on helping the students articulate their ideas and put them on paper in a drawing. Marcelo circulated amongst the tables, pressing the students to explain their ideas and their choice of materials. For example, one student exclaimed that they should build a dam, to which the mentor at his table replied that was one option and then solicited other options. Oliver, a mentor at another table, asked the student to explain his proposed solution to his mother to ensure he understood it and to solicit the mother's ideas. The student turned to his mother and explained how the polymer worked and what this might mean for the protection of the town—using the correct term, "polymer." At a third table, a student called out a question about how they could use the materials—*could they cut open the diaper to extract the sodium polyacrylate*? Marcelo responded that they could, which prompted a rush of several boys to grab a diaper and scissors. The students returned to their tables with a diaper and began to deconstruct them. As a visiting older brother began to use scissors to cut open the diapers, the younger brother, a fourth-grade student, stopped him and handed him safety glasses, reminding him that he needed to use them if he worked with the polymers. The students continued to work this way for about 15 minutes, experimenting with different materials and configurations of materials and rearranging or adding objects in response to the mentors' questions.

The testing of students' solutions offered an additional opportunity to engage in engineering discourse. After Marcelo announced that time was up, the students raised their hands in the air and stepped back from their creations. Marcelo continued: now, the students would engage in the first round of testing. The first team to go comprised two students and a father. One of the students explained their design (houses at the bottom of the tray nestled into sand and behind a dam made of sodium polyacrylate, which was meant to absorb the water so it could not knock the houses over) and their choice of materials, including the polymer. Then the other students gathered around as the lead mentor measured out one cup of water and poured it down the tray. The students observed and shouted, "cool!" jumping in the air and punching their fists upwards as they watched the water descend and knock down the "houses." The test was repeated with the remaining groups and to similar acclaim. One design stood out because, as the student creator explained, they had decided to elevate the "houses" on the rocks, which meant that the water did not touch the houses. The students all murmured how this was a good idea, offering their thoughts about adapting their design strategy. Marcelo prompted them to consider which other materials made a difference, and they settled on the sodium polyacrylate. One of the students shouted, "Polymers are the best thing that ever happened!"

Optimizing. After the first build and discussion of the first water test results, the students returned to their tables and eagerly redesigned their trays. Some students relied entirely on the polymer, deconstructing multiple diapers. One student used sticks to elevate his houses as if on stilts, as is common along the Texas coast, in addition to creating a polymer barrier. The mentors continued to question their redesigns, asking why the students thought their materials and configurations would protect the houses better. The students pointed to the initial test results—the elevated house and the polymer.

After another 10 minutes, the students were ready to re-test their designs. One of the mentors asked the students to think for a moment and predict which would hold up best versus worse and why. The students turned to their groups to confer. They then began to call out their predictions. The mentors encouraged them to explain why their prediction was reasonable, given the previous test and what they knew about the materials. After they made their predictions about which town would best withstand one cup of water, the lead mentor asked them how many cups of water they predicted it would take to leave the town flooded. Students looked back to their designs, pointing to the amount of polymer they had (or had not) used to make their predictions. After each group had made their predictions, the mentors poured the first and then subsequent cups of water, revisiting the predictions as the students cheered and booed the results.

Identity as Subjective/Social

The mentors supported the development of students' emerging engineering identities by providing external recognition. The mentors did this through positive discourse around the students' engineering work. The mentors' recognition of the students' work was important because the students often struggled to design, build, and test solutions. At the same time, the students clearly relished the mentors' praise and often danced or shouted happily when they completed a task successfully. To paint a picture of the external recognition that the mentors provided, we draw primarily on our observations to highlight one representative example of how the mentors affirmed the students and their work. In this example, we describe a bioengineering activity as it played out in the fall of 2018 at Jordan.

The purpose of the activity, which they began on a Tuesday and completed on the Saturday of that week, was to create a model of a clogged artery and then design a tool to unclog it. The activity's context, which excited the boys, was NBA player Chris Bosh, who was hospitalized in 2014 with a pulmonary embolism, which occurred because repeated blood clots blocked an artery in his lungs. A student-teacher led the session, and the mentors sat at the tables with the students. The teacher announced, "Today, you're all going to become bioengineers so we can figure out a solution for Chris Bosch so he can keep playing basketball." The students quieted down, interested to hear more about the basketball player and the health condition that almost ended his life. Throughout the afternoon, the mentors encouraged the students to work together as a team—like engineers do—praising them as they progressed with their models of the clogged artery. Once they had completed their models, the students tested their models using water to see whether having a clogged artery made a difference. Specifically, the students poured 100 ml of water through a cleared tube and the same amount through the blocked artery model, using a stopwatch to test whether there was a difference in the time it took for the water to pass entirely through. The mentors observed while the students measured and then poured the water, ensuring that they recorded the times and helped them draw conclusions.

We observed how the mentors affirmed students' ideas and work during the design phase during the Saturday session. Two students (Landyn and Charles), two mentors (Cassandra and David), and several guest mentors from a local association of Black professionals attended the Saturday session. The goal was to create a tool to clear out the clogged artery. The two students in attendance were both fourth graders and in their first semester in the program. Throughout the semester, Charles often appeared uninterested in the work and spent much of his time talking about basketball and eventually missed several sessions toward the end of the semester because of basketball practice. For example, during the session we describe below, one of the guest mentors explains that engineers make good money because they solve challenging problems. Charles responded forcefully that he was going to be a basketball player and not an engineer. Despite his apparent indifference, Charles enjoyed spending time with his friends and generally got along well with the other boys in the program. Landyn, in contrast, was openly interested in the engineering activities but struggled to work well with the other boys and improve on design errors.

The two students worked separately, each with a guest mentor, to re-create the clogged artery model. Then, they used materials including playdoh, paper clips, popsicle sticks, and rubber bands to design and build a tool to try to "unclog" the model artery. Both students struggled to think of ways to use the materials to create a tool. The guest mentors made suggestions and then praised the students' work as they began to draw and describe their ideas. With their designs complete, the students began to open the paper clips and stick them to the popsicle sticks with playdoh and the rubber bands. Charles finished his prototype before Landyn and chatted eagerly with the guest mentors and David about his design and tool, which he thought were cool.

David and Cassandra also offered positive affirmations of students' completed work. Once the students had completed their tools, they tested them using the tool to try to push out the playdoh in the clogged artery model. Both students found that it was more challenging than they thought it would be because the playdoh's resistance in the model bent or even broke off the paper clips, which both students were using as part of the tool to push the playdoh out. At one point, Landyn's tool got stuck in the model artery, and he lost his temper. Cassandra asked him how he might alter the tool so that it did not get stuck and then brainstormed ideas with him. She suggested inserting the tool from the other side of the tube, which he did, and he managed to dislodge some of the playdoh; Landyn declared, "It's working!" and Cassandra praised his persistence and the tool. As the activity wound down and both boys were able to clear out the model artery, one of the mentors applauded and told them that both teams had "saved Chris Bosh."

The Program Components as Protective

Protective Against a Lack of Belonging

In this section, we provide evidence of how the mentors created a sense of belonging among the students and how the students expressed a sense of belonging within the program. The mentors created a sense of belonging among the students by cultivating friendship with the boys and by providing academic and socioemotional support, interactions we describe at greater length in Snodgrass Rangel et al. (2020).

Sense of Belonging through Friendship. Some of the friendships occurred during the sessions, when the mentors joked around with the students, while others occurred before or after the official sessions. As an example of how the mentors acted as friends during sessions, Oliver described how his ability to joke helped cultivate strong relationships with the students: "So, we tell jokes, and basically, it's like almost I'm like their big brother" (S18, Charter). Luis described how he drew pictures for the students (something the students told us about in their interviews as well):

> I've made them all drawings. I'm about to give it to them in an hour or two. I just asked them, "If there's one thing you could draw for me, what would it be?" They told me something, and I just drew it for them. It's just a little sketch or whatever. It's just something nice to do to show them like, "Hey. I really appreciate you paying attention and coming to STEM" because it's an afterschool program. They don't have to come there. (S19, Charter)

The mentors also cultivated their friendships outside of the official sessions. For instance, several mentors at Jordan described how the mentors played basketball with the boys after the program. At Chavez, the mentors played soccer with the students after the program session had been completed. The mentors at Chavez also arrived early at the school, which enabled them to talk and connect with the boys about their interests. Yonatan recounted, "So, then they would come in, probably like—most of them would already be there by 3:30…So, I would just kind of let them do their thing, and we would just talk about how their days went" (F19, Chavez).

The young students we spoke to also felt that they had become friends with their mentors. Notably, the students connect the mentors' words and actions to their sense of belonging in the program. For example, several boys at Charter told us that they considered the mentors family. One said, "they're always fighting for you. Not literally, but they're always protecting you…they're like families [*sic*]. They treat us very nice" (F18). Another explained that spending time with the mentors was "like making a whole another [*sic*] family, but it's in science" (F18). A student at Jordan told us he hoped that one mentor, in particular, would stay at the school site, a reaction to the fact that not all of the mentors stayed more than one semester, and those who did sometimes rotated to other sites. In our interview, he asked us to pass along the following message: "Mr. Jorge, 'I'll give you $1 million if you stay the whole time'" (S19). Another student at Jordan told us that he liked the mentors because "they talk to us, they helped us, and maybe we did get in trouble, some people got mad, but everybody still likes the mentors so much because they were like friends" (F18). A student at Charter explained to us that his favorite mentor was Luis because he gave all of the students special drawings, adding, "he's actually funny. He is a really good artist. He also knows how to help people" (Charter student, S19). A student at Chavez simply said, "They're nice, friendly, fun" (Student 21, F19).

Sense of Belonging through Support. In this section, we share examples of how the students described how the mentors created a sense of belonging by providing support, both academic and socioemotional. For example, a student at Jordan recounted how one of the mentors was very nice, elaborating that, "she could understand us like—…if we're having a bad day, we will tell her what's going on, and she will understand" (Student 21, F19). Another student at Jordan had a similar experience with the same mentor. He recounted how "She would calm us down. She would tell us, 'Why don't we just work on this project, and we'll be a team together and work together?'" (Jordan, S19). A student at Chavez described how the mentors "teach us new things. We learned who made things and why. They teach us how to do something better" (Student 25, F19). Finally, a student at Charter explained how the mentors helped them throughout the sessions. He told us, "[one mentor] helped us with so many problems I can't even remember how much. The other mentors, too, plus they held with a program that they basically—without the mentors, we wouldn't be in this program today" (S19).

Protective Against Identity Interference

Role Models. We heard from a handful of students explicitly how they looked up to the mentors as role models. Though not as common as other ways the mentors and students connected, we heard about two ways in which the mentors were role models. First, two students said that being of the same race or ethnicity made them feel closer to the mentors. For example, Rogelio, a student at Jordan, explained that he connected with one mentor in particular, pointing in part to their shared ethnicity. He stated that "Mr. Jorge was also fun and he was the leader of our electricity project that I did. He is also Mexican like me" (S19). A student at Charter also told us that he liked how the mentors and the scientists of the week looked like him. Seeing the mentors and the diverse scientists made him feel proud and curious about what other great minds and inventors he had not been taught about yet. This student, who was Black, said to us,

> They're amazing engineers and careers. A lot of them—I'm not making controversy—but a lot of them was Black. I enjoy that because I like to see a lot of Black scientists actually getting put up and showing them, instead of hiding in the dark….So, I have to question myself who else is out there that we don't know. I saw lots of Black scientists that I really enjoyed. (Charter, S18)

The effect of the racial or ethnic matching is that it demonstrates to the students that engineers can look like them—and that people such as themselves can be engineers (Alston et al., 2017; Mondisa, 2018; Rosenthal et al., 2013; Shin et al., 2016; Young et al., 2013).

Second, several students described how working with the mentors made them think about STEM careers as possibilities. For instance, Sam, a student at Jordan, explained that the mentors "are nice and they're cool. They can help you be an engineer" (Jordan, F19). Similarly, a student at Charter told us that talking and learning about Scientists and Engineers of Color with the mentors made him think about a STEM career. He recounted how, "we talked about doctors and engineers and it made me want to be an engineer and a doctor to save people's lives and to build new things for the world" (F18). In short, the mentors helped the students see STEM careers generally and engineering in particular as desirable careers.

Shared Interests. The students also described the interests and hobbies they shared with the mentors. These shared interests were the focus of the many informal conversations that we heard about and that likely were instrumental in helping the students connect to the mentors as people and see similarities between themselves and the mentors. For example, a student at Charter told us that he liked solving Rubik's cubes, an interest he shared with one of the mentors. He said,

> Respondent: He could solve those dices.
> Moderator: Like a Rubik's cube?
> Respondent: Yes, a Rubik's cube very fast. He's like this [moves hands], not even looking. (S19)

A student at Jordan described who his favorite mentor was and why in this way: "Mr. Luis, he liked anime, and he was really fun to talk to. I usually worked with him when it was the first semester" (S19). Another student at Jordan described how his favorite mentor watched the same TV show as he did: "He was really nice and he also likes a TV show that I like to watch a lot" (F18). Finally, most of the students at Jordan told us that they loved playing basketball with the mentors after the session ended. At the same time, most of the students at Chavez recounted how they loved playing soccer with the mentors after the session.

Discussion

The purpose of this study was to identify how two program components that increasingly are common across afterschool engineering programs—engineering design activities and mentors—connect to the development of engineering identities in elementary-aged Black and Brown boys. This section highlights our contributions to research on engineering identity, describes the limitations of our study, and offers several implications for practice.

Implications for Research

Our study contributes to filling the gaps in STEM and engineering identity research in three ways.

Conceptual Clarity

Our first key contribution to research on engineering identity is conceptual clarity. Though there has been much research on STEM identity and a growing amount of research on engineering identity, how identity is conceptualized is inconsistent. Drawing on recent research syntheses of STEM (Radovic et al., 2018; Simpson & Bouhafa, 2020) and engineering (Morelock, 2017; Rodriguez et al., 2018) identity, we offer a conceptual model that connects two dimensions of identity—the representational/enactment and subjective/social dimensions—to one afterschool STEM program's key components. We describe how the program components are constructive (i.e., engineering design activities) and protective (i.e., program mentors). The engineering design activities proactively enhance identity while the program mentors are protective against common barriers facing marginalized students.

Engineering Identity Among Young Students

Second, we focus on how the program enhances engineering identity development in young students. Unlike college-aged engineering majors, most elementary students who participate in afterschool engineering programs such as the one described here likely are encountering engineering for the first time and have little context for what engineering is (Capobianco et al., 2011; Cunningham et al., 2005; Knight & Cunningham, 2004; Mena et al., 2009; Oware et al., 2007). Prior research demonstrates the importance of symbols (e.g., students wearing white lab coats are more likely to be perceived by others as science people; Jones et al., 2019) as well as authentic activities (Adams & Gupta, 2013; Aschbacher et al., 2010; Major & Kirn, 2017; Olitsky, 2007; Packard & Nguyen, 2003; Radovic et al., 2018; Simpson & Bouhafa, 2020; Yoon et al., 2014) and discourse, both of which help develop specialized vocabulary and cultural knowledge (Brown, 2004; Brown et al., 2005; Dou et al., 2019; Radovic et al., 2018; Ryu et al., 2019; Tonso, 2006a). Our work provides additional evidence of this constructive pathway connecting enactment of engineering work to identity but does so in the context of elementary-aged students. We identify the mechanism using our framework, highlighting that the afterschool engineering program connects to engineering identity via the representational/enactment dimension of identity. This dimension of identity allows students to be engineers through hands-on engineering design activities as students engage in engineering work and discourse (Radovic et al., 2018; Simpson & Bouhafa, 2020).

Engineering Identity and Black and Brown Boys

Our third contribution is to our understanding of how the program components can play a protective role among Students of Color. Protective factors seek to address or mitigate the barriers that marginalized students, particularly Black and Brown boys, face when engaging with exclusive spaces such as engineering. Prior research highlights multiple barriers to STEM and engineering identity development among Black and Brown boys, including a lack of a sense of belonging (Collins, 2018; McGee, 2016, 2020; McGee & Martin, 2011; Tan & Calabrese Barton, 2016) and identity interference (Archer et al., 2014). Many researchers have argued that mentors and role models from the same race, ethnicity, or gender can make marginalized students feel like they belong and help them see themselves as STEM people (McLean et al., 2020; Mondisa, 2018; Mondisa & McComb, 2018; Shin et al., 2016), and our findings support this argument. We provide evidence that matching mentors (role models) to their mentees based on race or ethnicity can help the young Students of Color see that engineering is possible. Based on our findings, we add that it is essential that the mentors share the elementary students' interests (e.g., video games) and also understand the popular culture references students make during sessions (e.g., to video games, to TV shows, to comic books). These shared interests create additional opportunities for informal conversations that develop deeper relationships between the mentors and mentees.

We also note that the friendships that developed with the mentors in the program throughout the boys' participation helped enhance the sense of community and belonging. The affective and supportive relationships that the mentors developed with the boys over one or more semesters may help the boys overcome any sense that engineering is not for them or conflicts with identities they already have (Archer et al., 2014; Collins, 2018). In this way, friendship may be a critical mechanism among young Black and Brown boys, who otherwise may be quick to dismiss engineering as uncool and not for them because of how they have been marginalized from engineering (Archer et al., 2014; DeWitt et al., 2013).

Limitations

As with any study, ours had its limitations. First, the generalizability of our findings may be limited by our focus on a small sample of students and mentors participating in a single afterschool engineering program. Our findings may not generalize to different programs, such as those that serve girls instead of or in addition to boys or those that do not have mentors. Future research should examine the mechanisms we have identified in other afterschool STEM and engineering programs. A second limitation is that we spoke to the mentors and students only once a semester during the study, and so we were asking them to recall experiences that may have happened eight or nine weeks prior. Our use of the observations was meant, in part, to mitigate this effect, but it does not overcome it. Future research should consider following fewer students and mentors but interviewing them more frequently or even collecting data in other ways, such as through regular journaling. A third limitation is that we have not connected the mechanisms to measures of students' engineering identity; instead, we focused on identifying how an informal engineering program can enhance their identity. A final limitation is that our design is not longitudinal in that we did not follow specific students over time as they engaged with the program activities and mentors. For this reason, we are not able to speak directly to the third dimension that Radovic and colleagues (2018) identify—the malleable nature of identity. Future research should connect the mechanisms we have identified to the changing nature of participants' engineering identities.

Implications for Practice

Our findings point to four implications for engineering educators working in informal settings. The first is that mentors play a decisive protective role in making engineering more accessible for young children and Black and Brown boys in particular. There are other informal engineering programs that integrate mentors, such as the BULLS-EYE Mentoring program at the University of South Florida, which works with middle schoolers, and the STOMP program at Tufts University, which works with elementary school students; we encourage the proliferation of this program model. Existing afterschool engineering programs that do not already incorporate undergraduate STEM mentors should do so, and universities should support STEM and engineering mentoring programs for elementary students as a way to help mitigate barriers that historically marginalized youth commonly encounter in STEM and engineering spaces.

A second recommendation is that existing STEM or engineering mentor programs should work to retain their mentors. Mentor retention is a common challenge for programs (Drew, 2018; McMorris et al., 2018; Raposa et al., 2017), but our findings suggest that retaining mentors is essential for developing deeper relationships with mentees and mentors. One way to address retention is through purposeful recruitment—recruiting mentors who have strong intrinsic motivations and who are not about to graduate and therefore could, in theory, serve longer as mentors (Snodgrass Rangel et al., 2021). A second way to address retention is to cultivate mentors' sense of self-efficacy (Parra et al., 2002; Rhodes, 2002; Snodgrass Rangel et al., 2021). Extrinsic motivators, such as payment, course credit, or other transactional benefits (Ragins & Scandura, 1999), may be useful for motivating mentors to give it a try (Nelson et al., 2017). However, they may be insufficient to retain them when the work becomes more challenging (Snodgrass Rangel et al., 2021).

A third and related recommendation is to seek mentors who share experiences and culture with the students participating in the program. Research is somewhat mixed on the importance of matching mentors to mentees in terms of gender, race, or ethnicity (Cheryan et al., 2013; Marx & Ko, 2012; Marx et al., 2009, 2013; McLean et al., 2020; Shin et al., 2016), but our findings suggest that the shared experiences associated with gender, race, or ethnicity help young students see engineering as both possible and desirable.

A fourth implication is that mentors and program staff should receive explicit training to support identity development in their mentees. Mentors need to understand that they play an essential role in imparting content knowledge and cultivating a trusting and caring relationship with their mentees. As part of that, they should be encouraged to start or engage in conversations around the students' interests. Mentors also need to learn about the importance of their affirmation of the students' struggle and their final products. We recommend that training engage the mentors in role-play and provide them with opportunities to see what these mentoring behaviors look like, either in videos or through observations. Fifth and finally, we recommend that program designers learn about incorporating young students' interests into the engineering design activities. Students are more likely to get excited about projects that address topics they care about, such as basketball, or are relevant to their experiences, such as the flooding activity.

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References

Adams, J. D., & Gupta, P. (2013). I learn more here than I do in school. Honestly, I wouldn't lie about that: Creating a space for agency and identity around science. *International Journal of Critical Pedagogy*, *4*(2), Article 2. http://libjournal.uncg.edu/ijcp/article/view/401

Allen, P. J., Chang, R., Gorrall, B. K., Waggenspack, L., Fukuda, E., Little, T. D., & Noam, G. G. (2019). From quality to outcomes: A national study of afterschool STEM programming. *International Journal of STEM Education*, *6*(1), 37. https://doi.org/10.1186/s40594-019-0191-2

Allie, S., Armien, M. N., Burgoyne, N., Case, J. M., Collier-Reed, B. I., Craig, T. S., Deacon, A., Fraser, D. M., Geyer, Z., Jacobs, C., Jawitz, J., Kloot, B., Kotta, L., Langdon, G., le Roux, K., Marshall, D., Mogashana, D., Shaw, C., Sheridan, G., & Wolmarans, N. (2009). Learning as acquiring a discursive identity through participation in a community: Improving student learning in engineering education. *European Journal of Engineering Education*, *34*(4), 359–367. https://doi.org/10.1080/03043790902989457

Alston, G. D., Guy, B. S., & Campbell, C. D. (2017). Ready for the professoriate? The influence of mentoring on career development for Black male graduate students in STEM. *Journal of African American Males in Education (JAAME)*, *8*(1), 45–66.

Archer, L. (2008). The impossibility of minority ethnic educational "success"? An examination of the discourses of teachers and pupils in British secondary schools. *European Educational Research Journal*, *7*(1), 89–107.

Archer, L., DeWitt, J., & Willis, B. (2014). Adolescent boys' science aspirations: Masculinity, capital, and power. *Journal of Research in Science Teaching*, *51*(1), 1–30. https://doi.org/10.1002/tea.21122

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation, and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching*, *47*(5), 564–582. https://doi.org/10.1002/tea.20353

Atwater, M. M. (2000). Equity for Black Americans in precollege science. *Science Education*, *84*(2), 154–179. https://doi.org/10.1002/(SICI)1098-237X(200003)84:2<154::AID-SCE2>3.0.CO;2-R

Baber, L. D. (2015). Considering the interest-convergence dilemma in STEM education. *Review of Higher Education*, *38*(2), 251–270. https://doi.org/10.1353/rhe.2015.0004.

Baldwin, T. B., Daniel, A., & Williams, B. (2016). Impact of an introductory engineering design course on minority middle and high school students' self-efficacy and interest in engineering (work in progress). *ASEE Annual Conference & Exposition, New Orleans, Louisiana*, *10*, 25532.

Bang, M., & Medin, D. (2010). Cultural processes in science education: Supporting the navigation of multiple epistemologies. *Science Education*, *94*(6), 1008–1026. https://doi.org/10.1002/sce.20392

Bang, M., Brown, B., Calabrese Barton, A., Rosebery, A., & Warren, B. (2017). Helping students make sense of the world using next generation science and engineering practices. In *Toward more equitable learning in science* (pp. 33–58). National Science Teachers Association.

Bang, M., Warren, B., Rosebery, A. S., & Medin, D. (2012). Desettling expectations in science education. *Human Development*, *55*(5–6), 302–318. https://doi.org/10.1159/000345322

Bodzin, A., & Gehringer, M. (2001). Breaking science stereotypes. *Science and Children*, *38*(4), 36–41.

Braden, S. K. (2020). "Scientists can't really talk to people": Unpacking students' metacommentary on the racialized and gendered science nerd trope. *International Journal of Multicultural Education*, *22*(2), 87–108. https://doi.org/10.18251/ijme.v22i2.2439

Brickhouse, N. W. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching*, *38*(3), 282–295.

Brown, B. A. (2004). Discursive identity: Assimilation into the culture of science and its implications for minority students. *Journal of Research in Science Teaching*, *41*(8), 810–834. https://doi.org/10.1002/tea.20228

Brown, B. A., Reveles, J. M., & Kelly, G. J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning. *Science Education*, *89*(5), 779–802. https://doi.org/10.1002/sce.20069

Bullock, C. E. (2017). Only STEM can save us? Examining race, place, and STEM education as property. *Educational Studies*, *53*(6), 628–641. https://doi.org/10.1080/00131946.2017.1369082

Calabrese Barton, A., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *Journal of the Learning Sciences*, *19*(2), 187–229. https://doi.org/10.1080/10508400903530044

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal*, *50*(1), 37–75. https://doi.org/10.3102/0002831212458142

Capobianco, B. M. (2006). Undergraduate women engineering their professional identities. *Journal of Women and Minorities in Science and Engineering, 12*(2–3). doi.org/10.1615/JWomenMinorScienEng.v12.i2-3.10

Capobianco, B. M., Diefes-dux, H. A., Mena, I., & Weller, J. (2011). What is an engineer? Implications of elementary school student conceptions for engineering education. *Journal of Engineering Education*, *100*(2), 304–328. https://doi.org/10.1002/j.2168-9830.2011.tb00015.x

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Cheryan, S., Drury, B. J., & Vichayapai, M. (2013). Enduring influence of stereotypical computer science role models on women's academic aspirations. *Psychology of Women Quarterly*, *37*(1), 72–79. https://doi.org/10.1177/0361684312459328

Chu, L., Sampson, V., Hutner, T., Rivale, S., Crawford, R., Baze, C., & Brooks, H. (2019). Argument-driven engineering in middle school science: An exploratory study of changes in engineering identity over an academic year. *Journal of Pre-College Engineering Education Research (J-PEER)*, *9*(2). https://doi.org/10.7771/2157-9288.1249

Collins, K. H. (2018). Confronting color-blind STEM talent development: Toward a contextual model for Black student STEM identity. *Journal of Advanced Academics*, *29*(2), 143–168. https://doi.org/10.1177/1932202X18757958

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, *39*(3), 124–130.

Cunningham, C. M., Lachapelle, C., & Lindgren-Streicher, A. (2005). Assessing elementary school students' conceptions of engineering and technology. *American Society for Engineering Education Annual Conference & Exposition*, 11.

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B*, *2*(1), 63–79. https://doi.org/10.1080/21548455.2011.629455

Daugherty, J. L., & Custer, R. L. (2012). Secondary level engineering professional development: Content, pedagogy, and challenges. *International Journal of Technology and Design Education*, *22*(1), 51–64. https://doi.org/10.1007/s10798-010-9136-2

Denzin, N. K. (1978). *The research act: A theoretical orientation to sociological methods* (2nd ed.). McGraw-Hill.

DeWitt, J., Archer, L., & Osborne, J. (2013). Nerdy, brainy and normal: Children's and parents' constructions of those who are highly engaged with science. *Research in Science Education*, *43*(4), 1455–1476. https://doi.org/10.1007/s11165-012-9315-0

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education*, *103*(3), 623–637. https://doi.org/10.1002/sce.21499

Drew, A. L. (2018). *Understanding mentors' experiences in order to improve mentor retention: A three-study, multi-method dissertation* [Doctoral dissertation, Boston University]. http://search.proquest.com/docview/2155480288/abstract/EB27704B02D64E91PQ/1

Du, X.-Y. (2006). Gendered practices of constructing an engineering identity in a problem-based learning environment. *European Journal of Engineering Education*, *31*(1), 35–42. https://doi.org/10.1080/03043790500430185

Dukhan, N., Schumack, M. R., & Daniels, J. J. (2008). Implementation of service-learning in engineering and its impact on students' attitudes and identity. *European Journal of Engineering Education*, *33*(1), 21–31. https://doi.org/10.1080/03043790701746132

Eccles, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J., Midgley, C. (1983). *Expectancies, values and academic behaviors*. Freeman.

Eliot, M., & Turns, J. (2011). Constructing professional portfolios: Sense-making and professional identity development for engineering undergraduates. *Journal of Engineering Education*, *100*(4), 630–654. https://doi.org/10.1002/j.2168-9830.2011.tb00030.x

Faulkner, W. (2007). "Nuts and bolts and people": Gender-troubled engineering identities. *Social Studies of Science*, *37*(3), 331–356. https://doi.org/10.1177/0306312706072175

Fetterman, D. M. (2019). *Ethnography: Step-by-step* (Vol. 17). SAGE Publications.

Fox, M. F. (2006). Women, men, and engineering. *Women, Gender, and Technology*, 47–59.

Funk, C., & Parker, K. (2018, January 9). *Diversity in the STEM workforce varies widely across jobs*. Pew Research. https://www.pewsocialtrends.org/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/

Gonsalves, A., Rahm, J., & Carvalho, A. (2013). "We could think of things that could be science": Girls' re-figuring of science in an out-of-school-time club. *Journal of Research in Science Teaching*, *50*(9), 1068–1097. https://doi.org/10.1002/tea.21105

Grossman, J. M., & Porche, M. V. (2014). Perceived gender and racial/ethnic barriers to STEM success. *Urban Education*, *49*(6), 698–727. https://doi.org/10.1177/0042085913481364

Hampton, C., Reeping, D., & Ozkan, D. S. (2021). Positionality statements in engineering education research: A look at the hand that guides the methodological tools. *Studies in Engineering Education*, *1*(2), 126–141. https://doi.org/10.21061/see.13

Henfield, M. S. (2012). Masculinity identity development and its relevance to supporting talented Black males. *Gifted Child Today*, *35*(3), 179–186. https://doi.org/10.1177/1076217512444547

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. American Association of University Women.

hooks, bell. (2004). *We real cool: Black men and masculinity*. Routledge.

Hynes, M., Portsmore, M., Dare, E., Milto, E., Rogers, C., Hammer, D., & Carberry, A. (2011). Infusing engineering design into high school STEM courses. *NCETE*, 1–7. https://digitalcommons.usu.edu/ncete_publications/165

Jones, M. G., Lee, T., Chesnutt, K., Carrier, S., Ennes, M., Cayton, E., Madden, L., & Huff, P. (2019). Enclothed cognition: Putting lab coats to the test. *International Journal of Science Education*, *41*(14), 1962–1976. https://doi.org/10.1080/09500693.2019.1649504

Knight, M., & Cunningham, C. (2004). Draw an Engineer Test (DAET): Development of a tool to investigate students' ideas about engineers and engineering. *American Society for Engineering Education Annual Conference & Exposition*, 11.

Kupersmidt, J., Stelter, R., Garringer, M., & Bourgoin, J. (2018). *STEM mentoring: Supplement to the elements of effective practice for mentoring*. MENTOR: The National Mentoring Partnership.

Lachapelle, C. P., & Cunningham, C. M. (2017). Elementary engineering student interests and attitudes: A comparison across treatments. *ASEE Annual Conference and Exposition, Conference Proceedings*, *June 2017*. https://pennstate.pure.elsevier.com/en/publications/elementary-engineering-student-interests-and-attitudes-a-comparis

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. SAGE.

Mack, K. M., Winter, K., & Soto, M. (2019). *Culturally responsive strategies for reforming STEM higher education: Turning the TIDES on inequity*. Emerald Group Publishing.

Major, J. C., & Kirn, A. (2017). Engineering identity and project-based learning: How does active learning develop student engineering identity. *Proceedings ASEE 2017 Annual Conference and Exposition*. American Society for Engineering Education.

Malone, K. R., & Barabino, G. (2009). Narrations of race in STEM research settings: Identity formation and its discontents. *Science Education*, *93*(3), 485–510. https://doi.org/10.1002/sce.20307

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education*, *32*(5), 669–685. https://doi.org/10.1080/09500690902792385

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education*, *95*(5), 877–907. https://doi.org/10.1002/sce.20441

Manuel, M., Greer, R. P., Henderson, J. A., & Rangel, V. S. (2018, June). Engagement in practice: STEM engagement through mentoring. In *2018 ASEE Annual Conference & Exposition*.

Marx, D. M., & Ko, S. J. (2012). Superstars "like" me: The effect of role model similarity on performance under threat. *European Journal of Social Psychology*, *42*(7), 807–812. https://doi.org/10.1002/ejsp.1907

Marx, D. M., Ko, S. J., & Friedman, R. A. (2009). The "Obama effect": How a salient role model reduces race-based performance differences. *Journal of Experimental Social Psychology*, *45*(4), 953–956. https://doi.org/10.1016/j.jesp.2009.03.012

Marx, D. M., Monroe, A. H., Cole, C. E., & Gilbert, P. N. (2013). No Doubt about it: When doubtful role models undermine men's and women's math performance under threat. *Journal of Social Psychology*, *153*(5), 542–559. https://doi.org/10.1080/00224545.2013.778811

McGee, E. O. (2016). Devalued Black and Latino racial identities: A by-product of STEM college culture? *American Educational Research Journal*, *53*(6), 1626–1662. https://doi.org/10.3102/0002831216676572

McGee, E. O. (2020). Interrogating structural racism in STEM higher education. *Educational Researcher*, *49*(9), 633–644. https://doi.org/10.3102/0013189X20972718

McGee, E. O., & Martin, D. B. (2011). "You would not believe what I have to go through to prove my intellectual value!" Stereotype management among academically successful Black mathematics and engineering students. *American Educational Research Journal*, *48*(6), 1347–1389. https://doi.org/10.3102/0002831211423972

McLean, M., Nation, J., Spina, A., Susko, T., Harlow, D., & Bianchini, J. (2020). The importance of collaborative design for narrowing the gender gap in engineering: An analysis of engineering identity development in elementary students. *Journal of Pre-College Engineering Education Research (J-PEER)*, *10*(2). https://doi.org/10.7771/2157-9288.1210

McMorris, B. J., Doty, J. L., Weiler, L. M., Beckman, K. J., & Garcia-Huidobro, D. (2018). A typology of school-based mentoring relationship quality: Implications for recruiting and retaining volunteer mentors. *Children and Youth Services Review*, *90*, 149–157. https://doi.org/10.1016/j.childyouth.2018.05.019

Mejia, J. A., Revelo, R. A., Villanueva, I., & Mejia, J. (2018). Critical theoretical frameworks in engineering education: An anti-deficit and liberative approach. *Education Sciences*, *8*(4), 158. https://doi.org/10.3390/educsci8040158

Mena, I. B., Capobianco, B., & Diefes-Dux, H. A. (2009). Significant cases of elementary students' development of engineering perceptions. *American Society for Engineering Education Annual Conference & Exposition*.

Milner, H. R. (2007). Race, culture, and researcher positionality: Working through dangers seen, unseen, and unforeseen. *Educational Researcher*, *36*(7), 388–400. https://doi.org/10.3102/0013189X07309471

Mondisa, J.-L. (2018). Examining the mentoring approaches of African-American mentors. *Journal of African American Studies*, *22*(4), 293–308. https://doi.org/10.1007/s12111-018-9411-y

Mondisa, J.-L., & McComb, S. A. (2015). Social community: A mechanism to explain the success of STEM minority mentoring programs. *Mentoring & Tutoring: Partnership in Learning*, *23*(2), 149–163. https://doi.org/10.1080/13611267.2015.1049018

Mondisa, J.-L., & McComb, S. A. (2018). The role of social community and individual differences in minority mentoring programs. *Mentoring & Tutoring: Partnership in Learning*, *26*(1), 91–113. https://doi.org/10.1080/13611267.2018.1445432

Moore III, J. L., Madison-Colmore, O., & Smith, D. M. (2003). The prove-them-wrong syndrome: Voices from unheard African-American males in engineering disciplines. *Journal of Men's Studies*, *12*(1), 61–73. https://doi.org/10.3149/jms.1201.61

Morelock, J. R. (2017). A systematic literature review of engineering identity: Definitions, factors, and interventions affecting development, and means of measurement. *European Journal of Engineering Education*, *42*(6), 1240–1262. https://doi.org/10.1080/03043797.2017.1287664

Moreno, N. P., Tharp, B. Z., Vogt, G., Newell, A. D., & Burnett, C. A. (2016). Preparing students for middle school through after-school STEM activities. *Journal of Science Education and Technology*, *25*(6), 889–897. https://doi.org/10.1007/s10956-016-9643-3

National Academies of Science, Engineering, and Medicine. (2019). *The science of effective mentorship in STEMM*. The National Academies Press.

National Center for Education Statistics. (2019). *Indicator 26: STEM degrees*. National Center for Education Statistics. https://nces.ed.gov/programs/raceindicators/indicator_REG.asp

National Research Council. (2012). *Framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press. https://doi.org/10.17226/13165

National Science Foundation. (2020). *The state of U.S. science and engineering 2020*. https://ncses.nsf.gov/pubs/nsb20201/u-s-s-e-workforce

Nelson, K., Sabel, J., Forbes, C., Grandgenett, N., Tapprich, W., & Cutucache, C. (2017). How do undergraduate STEM mentors reflect upon their mentoring experiences in an outreach program engaging K-8 youth? *International Journal of STEM Education*, *4*(1), 1–13. https://doi.org/10.1186/s40594-017-0057-4

Next Generation Science Standards. (2013). https://www.nextgenscience.org/

Olitsky, S. (2007). Promoting student engagement in science: Interaction rituals and the pursuit of a community of practice. *Journal of Research in Science Teaching*, *44*(1), 33–56. https://doi.org/10.1002/tea.20128

Ortiz, N. A., Morton, T. R., Miles, M. L., & Roby, R. S. (2020). What about us? Exploring the challenges and sources of support influencing Black students' STEM identity development in postsecondary education. *Journal of Negro Education*, *88*(3), 311–326. https://doi.org/10.7709/jnegroeducation.88.3.0311

Oware, E., Capobianco, B., & Diefes-Dux, H. (2007). Gifted students' perceptions of engineers? A study of students in a summer outreach program. *Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition, Honolulu*.

Packard, B. W.-L., & Nguyen, D. (2003). Science career-related possible selves of adolescent girls: A longitudinal study. *Journal of Career Development*, *29*(4), 251–263. https://doi.org/10.1177/089484530302900403

Parra, G. R., DuBois, D. L., Neville, H. A., Pugh-Lilly, A. O., & Povinelli, N. (2002). Mentoring relationships for youth: Investigation of a process-oriented model. *Journal of Community Psychology*, *30*(4), 367–388. https://doi.org/10.1002/jcop.10016

Patrick, A., & Borrego, M. (2016). A Review of the literature relevant to engineering identity. *American Society for Engineering Education Annual Conference*.

Portsmore, M., Maltese, A. V., Miel, K., & Paul, K. (2019). *Exploring the impact of university engineering role models on elementary students*. American Society for Engineering Education.

Radovic, D., Black, L., Williams, J., & Salas, C. E. (2018). Towards conceptual coherence in the research on mathematics learner identity: A systematic review of the literature. *Educational Studies in Mathematics*, *99*(1), 21–42. https://doi.org/10.1007/s10649-018-9819-2

Ragins, B. R., & Scandura, T. A. (1999). Burden or blessing? Expected costs and benefits of being a mentor. *Journal of Organizational Behavior*, *20*, 493–509. https://doi.org/10.1002/(SICI)1099-1379(199907)20:43.0.CO;2-T

Raposa, E. B., Dietz, N., & Rhodes, J. E. (2017). Trends in volunteer mentoring in the United States: Analysis of a decade of census survey data. *American Journal of Community Psychology*, *59*(1–2), 3–14. https://doi.org/10.1002/ajcp.12117

Rhodes, J. (2002). *Stand by me: The risks and rewards of mentoring today's youth*. Harvard Education Press.

Rodriguez, S. L., Lu, C., & Bartlett, M. (2018). Engineering identity development: A review of the higher education literature. *International Journal of Education in Mathematics, Science and Technology*, *6*(3), 254–265. https://doi.org/10.18404/ijemst.428182

Rohde, J., Musselman, L., Benedict, B., Verdín, D., Godwin, A., Kirn, A., Benson, L., & Potvin, G. (2019). Design experiences, engineering identity, and belongingness in early career electrical and computer engineering students. *IEEE Transactions on Education*, *62*(3), 165–172. https://doi.org/10.1109/TE.2019.2913356

Rosenthal, L., Levy, S. R., London, B., Lobel, M., & Bazile, C. (2013). In pursuit of the MD: The impact of role models, identity compatibility, and belonging among undergraduate women. *Sex Roles*, *68*(7), 464–473. https://doi.org/10.1007/s11199-012-0257-9

Roy, J. (2018, July). *Engineering by the numbers*. ASEE. https://ira.asee.org/wp-content/uploads/2019/07/2018-Engineering-by-Numbers-Engineering-Statistics-UPDATED-15-July-2019.pdf

Ryu, M., Tuvilla, M. R. S., & Wright, C. E. (2019). Resettled Burmese refugee youths' identity work in an afterschool STEM learning setting. *Journal of Research in Childhood Education*, *33*(1), 84–97. https://doi.org/10.1080/02568543.2018.1531454

Saddler, T. (2010). Mentoring and African American undergraduate perceptions of academic success. In *The evolving challenges of Black college students: New insights for practice and research*. Stylus Publishing.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, *96*(3), 411–427. https://doi.org/10.1002/sce.21007

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences* (Vol. 12). Westview Press.

Shin, J. E. L., Levy, S. R., & London, B. (2016). Effects of role model exposure on STEM and non-STEM student engagement. *Journal of Applied Social Psychology*, *46*(7), 410–427. https://doi.org/10.1111/jasp.12371

Simpson, A., & Bouhafa, Y. (2020). Youths' and adults' identity in STEM: A systematic literature review. *Journal for STEM Education Research*. https://doi.org/10.1007/s41979-020-00034-y

Snodgrass Rangel, V., Henderson, J., Doan, V., Jones, S. J., Greer, R., & Manuel, M. (2020). Explaining variability in the implementation of an after-school STEM mentoring program. Accepted for presentation at the annual meeting of the American Educational Research Association http://tinyurl.com/r9e4ldu (Conference canceled).

Snodgrass Rangel, V., Jones, S., Doan, V., Henderson, J., Greer, R., & Manuel, M. (2021). The motivations of STEM mentors. *Mentoring and Tutoring: Partnership in Learning*, *29*(4), 353–388. https://doi.org/10.1080/13611267.2021.1954461

Sochacka, N. W., Walther, J., & Pawley, A. L. (2018). Ethical validation: Reframing research ethics in engineering education research to improve research quality. *Journal of Engineering Education*, *107*(3), 362–379. https://doi.org/10.1002/jee.20222

Starr, C. R. (2018). "I'm not a science nerd!" STEM stereotypes, identity, and motivation among undergraduate women. *Psychology of Women Quarterly*, *42*(4), 489–503.

Sue, D. W., Capodilupo, C. M., Torino, G. C., Bucceri, J. M., Holder, A. M. B., Nadal, K. L., & Esquilin, M. (2007). Racial microaggressions in everyday life: Implications for clinical practice. *American Psychologist*, *62*(4), 271–286. https://doi.org/10.1037/0003-066X.62.4.271

Tan, E., & Calabrese Barton, A. (2008). Unpacking science for all through the lens of identities-in-practice: The stories of Amelia and Ginny. *Cultural Studies of Science Education*, *3*(1), 43–71. https://doi.org/10.1007/s11422-007-9076-7

Tan, E., & Calabrese Barton, A. (2010). Transforming science learning and student participation in sixth grade science: A case study of a low-income, urban, racial minority classroom. *Equity & Excellence in Education*, *43*(1), 38–55. https://doi.org/10.1080/10665680903472367

Tan, E., & Calabrese Barton, A. (2016). Hacking a path in and through STEM: Unpacking the STEM identity work of historically underrepresented youth in STEM. In C. K. Looi, J. L. Polman, U. Cress, & P. Reimann (Eds.), *Transforming learning, empowering learners*. International Society of the Learning Sciences.

Texas Education Agency. (2019). *Texas academic performance report*. https://rptsvr1.tea.texas.gov/perfreport/tapr/2019/index.html

Tonso, K. L. (1999). Engineering gender-gendering engineering: A cultural model for belonging. *Journal of Women and Minorities in Science and Engineering*, *5*(4), 365–405. https://doi.org/10.1615/JWomenMinorScienEng.v5.i4.60

Tonso, K. L. (2006a). Teams that work: Campus culture, engineer identity, and social interactions. *Journal of Engineering Education*, *95*(1), 25–37. https://doi.org/10.1002/j.2168-9830.2006.tb00875.x

Tonso, K. L. (2006b). Student engineers and engineer identity: Campus engineer identities as figured world. *Cultural Studies of Science Education*, *1*(2), 273–307. https://doi.org/10.1007/s11422-005-9009-2

Vakil, S., & Ayers, R. (2019). *The racial politics of STEM education in the USA: Interrogations and explorations*. Taylor & Francis.

Van Sell, M., Brief, A. P., & Schuler, R. S. (1981). Role conflict and role ambiguity: Integration of the literature and directions for future research. *Human Relations*, *34*(1), 43–71.

Yin, R. K. (2002). *Case study research: Design and methods*. SAGE Publications.

Yoon, S. Y., Dyehouse, M., Lucietto, A. M., Diefes-Dux, H. A., & Capobianco, B. M. (2014). The effects of integrated science, technology, and engineering education on elementary students' knowledge and identity development. *School Science and Mathematics*, *114*(8), 380–391. https://doi.org/10.1111/ssm.12090

Young, D. M., Rudman, L. A., Buettner, H. M., & McLean, M. C. (2013). The influence of female role models on women's implicit science cognitions. *Psychology of Women Quarterly*, *37*(3), 283–292. https://doi.org/10.1177/0361684313482109

Yu, M. V. B., Liu, Y., Soto-Lara, S., Puente, K., Carranza, P., Pantano, A., & Simpkins, S. D. (2021). Culturally responsive practices: Insights from a high-quality math afterschool program serving underprivileged Latinx youth. *American Journal of Community Psychology*. https://doi.org/10.1002/ajcp.12518

Appendix A. *A Priori* and Emergent Codes for Thematic Analysis

- Program components as constructive (*a priori*)
  - Representational/enactment identity (*a priori*)
  - Subjective/social identity (*a priori*)
- Program components as protective (*a priori*)
  - Lack of belonging (*a priori*)
    - Friendship (emerging)
    - Support (emerging)
  - Identity interference (*a priori*)
    - Role models (emerging)
    - Shared interests (emerging)

Appendix B. Semi-structured Interview Protocols

Interview Protocol: Mentors

My name is ______ and I am helping with the research component of the [Program name]. In this interview, I am going to ask you about your experience as a mentor in the afterschool program. As we talk, I'd like you to think about your experiences, the students you worked with, and how the experience made you feel as a mentor, engineering student, and future professional. If at any time, you would like to stop the interview or you would like me to stop recording, please let me know. This interview should take about 30 minutes.

1. Background questions:
   a. [**ONLY FOR NEW MENTORS**] Have you volunteered or worked as a mentor before? Can you tell me more about what you did?
      i. Why did you get into volunteering/mentoring?
      ii. What do you think you got out of that experience?
2. [**ONLY FOR NEW MENTORS**] STEM background and identity: Questions about high school experiences:
   a. Tell me about your high school and your friends in high school—did you have other friends who were good at school and into STEM?
   b. How would you say you got into STEM? When did you decide that STEM was for you?
      i. Was there an "a-ha" moment?
   c. Can you tell me about a time in high school when you struggled in a science or math class, and how addressed it?
3. Questions about your experience as a mentor this semester
   a. [**ONLY FOR NEW MENTORS**] How did you learn about the mentoring program? [*Follow up on this to get details*]
   b. Can you tell me about how mentoring went this year/semester?
      i. How did you understand your role as a mentor? Can you describe a typical mentoring session?
      ii. [**FOR RETURNING MENTORS**] How did this last semester compare to previous semesters? What was similar/different?
   c. How confident do you feel in your abilities to mentor in the future?
   d. What experiences this semester or year have helped you to develop as a mentor?
   e. How well, do you believe, your mentees are responding to you as a mentor?
   f. Can you provide an example of how you successfully helped a mentee (meet and overcome a challenging obstacle) this past semester?

g. After your experiences, are you more or less likely to mentor in the future? Why?
h. Thinking as a [university] student, in what ways has being a mentor with this program changed how you think about the university, your major, or your career interests? Please be sure to explain.
i. Do you think you would want to serve as a mentor again with this or a similar program? Why or why not?
j. Would you recommend the program to other engineering students? What would you tell them?

4. Is there anything else you would like to add?

Student Questions

My name is ______, and I'm helping with the research component of this program. So, in this interview I'm going to ask you what you think about science, math, and engineering. I'm also going to ask you about the afterschool STEM program you participated in. If at any time you would like me to stop the interview or you would like me to stop recording just let me know. It should take about 30 minutes.

Academic Identity

- Do you enjoy going to school?
- What's your favorite subject in school? Why?
- When you are in [math/science class], how do you feel?

STEM Interest

- What was your favorite thing about the STEM program this semester?
- Do you enjoy doing the engineering activities in the STEM program?
- Do you share what you've learned in the STEM program with your friends or family?

Identity: Recognition from Others

- Do your parents/family like that you're in the STEM program? What are they saying?
- Do your teachers know that you're in the STEM program? What do they say?
- What did you think about the mentors? Why?
- What did you like or not like about working with them?
- What have the mentors said about how well you do in the STEM program?

Identity: Recognition from Self

- When you were doing the engineering activities, how did you feel?

Identity: What an Engineer Does and Looks Like

- What kinds of things does an engineer do at work?
- Draw an engineer: *Using these crayons, please take 5 minutes to draw an engineer.*
  - *Probes: Is this a man or a woman? Why did you draw the engineer that way? Why did you use the colors you did? Do you think this engineer looks like you?*
- Pictures of engineers: *Here are some pictures of people. I need you to tell me which person is an engineer and why you think so.*

Is there anything else you would like to add about the afterschool program?
Those are all of my questions, thank you!