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Keywords

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A Narrative Investigation of Black Familial Capital that Supports Engineering Engagement of Middle-School-Aged Youth

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Abstract

A major concern in engineering education involves ensuring that youth belonging to minoritized groups have equitable access to engineering career pathways. Related research often highlights the effect of student and school characteristics on engineering success but few studies have investigated the engineering-related assets that Black families provide. This work aims to provide counterstories that highlight the presence of Black families along the pre-college engineering pathways of three Black youth from the Midwest region of the United States. The application of a counternarrative approach centers the familial capital of Black families and serves as the analytical frame for this work. The interview instruments elicited narratives related to the quality and nature of the children's engineering experiences and family support. We found that Black families employed eight specific supportive practices. These findings provide evidence of ways that Black families support engineering learning and refute the positioning of Black families as resource-deficient and under-engaged. This work contributes to the engineering education and family studies fields.

Keywords: community cultural wealth, Black youth, middle school, engineering education, families

Introduction and Background

Although 13.4% of the U.S. population is Black, just 4.2% of engineering degrees in the USA are awarded to Black undergraduates (Roy, 2019) and 7.2% of the science and engineering workforce in the USA is Black (National Center for Science and Engineering Statistics, 2021). While we acknowledge the achievements of these Black engineers, this representation gap worries educators, researchers, policymakers, and industry for a variety of reasons and has implications for social and economic opportunities, innovative excellence, and the workforce (Gibbs, 2014; Hong & Page, 2004; National Academies of Sciences, Engineering, and Medicine [NASEM], 2019; Pew Research Center, 2018). Some have referred to this dilemma as a "leaky pipeline" (Wickware, 1997); however, this is not solely an economic concern. This disparity is an equity issue and social justice concern that has been characterized as more than just unfortunate truths but a consequence of systemic racism in the USA and changing demographics (Baber, 2015; NASEM, 2019). While the disparity is evident in undergraduate engineering degree programs and professional practice, pre-college experiences are a critical aspect of the larger conversation around racial equity and racial justice in engineering education (Martin & Wendell, 2021).

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Pre-college experiences serve as impactful opportunities for Black youth to consider and explore engineering as a field of study and a career path. These experiences are important because they can impact youth's interest in engineering and their science, technology, engineering, and mathematics (STEM) self-efficacy, particularly when the experiences allow Black youth to see how engineering aligns with their interests and values (e.g., Hynes & Maxey, 2018). This is important for addressing persistent racial injustice related to who is earning engineering degrees. Black engineers and community leaders have developed pre-college programs like the National Society of Black Engineers' Summer Engineering Experiences for Kids and the Detroit Area Pre-College Engineering Program (DAPCEP) for Black youth and other youth who are not historically represented in engineering. These programs often provide culturally relevant and sustaining learning experiences through curricula facilitated and designed by Black undergraduate STEM students, in-service teachers (Cardella et al., 2019; Fletcher, 2017), and mentors from local industries, universities, and informal science learning settings (DAPCEP, 2012).

However, when pre-college engineering curriculum is developed by members of dominant groups, it is important to consider whose experiences and ways of knowing matter and how they are pursuing and promoting equity in the curriculum (Bang et al., 2012; Nazar et al., 2019; Tan et al., 2019). In their essay on equity in the maker movement, Vossoughi et al. (2016) caution that the modes of inclusion practiced by dominant communities often can lead to positioning Communities of Color as "targets of intervention rather than sources of deep knowledge and skill, and dominant communities are reinscribed as being ahead, with something to teach or offer rather than something to learn" (p. 212). Therefore, researchers and educators, particularly those from dominant communities, must recognize that "inventing, making, tinkering, designing, are indigenous practices, that is, practices that originate and occur naturally in particular ecologies" (Schwartz & Gutierrez, 2015, p. 577). With this acknowledgment, we seek to understand and engage the existing impactful pre-college experiences that occur in Black families and communities.

Recent studies on the ways that families engage in engineering and STEM together provide some glimpses of the ways that youth and families are already involved in making, designing, and engineering and the ways that parent–child interactions can support science and engineering learning. For example, in a literature synthesis, Yun et al. (2010) identified four roles that parents play in science and engineering learning: engineering career mentor, engineering attitudes builder, students' achievement stimulus, and scientific/engineering thinking guider. Building on this work, Dorie et al. (2014) synthesized findings from five of their studies and found that parents (and other caregivers) also acted as engineering engagement advocates. Svarovsky and colleagues (2017) examined early parent–child interactions in museum-based settings and found that these interactions fostered engineering learning best when adults solicited the child's input on design decisions rather than being directive. In another study, Pattison and colleagues (2016, 2020) investigated early childhood engineering-related interest development for Head Start English- and Spanish-speaking families over six months and during a follow-up interview two years later. They observed parent awareness of the engineering design process and engineering-related awareness, knowledge, and skills; family re-engagement with engineering project materials, activities, and concepts for years after the initial study; and family use of the engineering design process in new environments. Finally, Ohland and colleagues (2019) investigated the child–parent interactions of families with 6- and 7-year-old children at a science center exhibit and extended the Yun et al. (2010) parental role framework to include the following roles: supervising/directing, co-learning, facilitation, student of the child, encouragement, and disengagement. Table 1 summarizes the findings on parental roles in the aforementioned scholarship. Though these works provide critical insight into parent–child interactions in informal design and engineering learning environments, more research is needed to explore the specific influence of Black parents and other family members in similar environments.

Therefore, in this study, we aimed to identify the engineering learning, teaching, and supportive practices that exist within Black families. As in similar studies (Nasir, 2005; Tõugu et al., 2017), parents and children who participated in this project were asked to report on their engineering interests, conversations, and engagement. By presenting the narratives of three middle-school-aged children and their parents, we were able to provide insights on the following question: *In what ways do Black families support their middle school children's engineering interests?* These findings have implications for research about Black families in STEM, with a specific focus on parental support along engineering pathways. These pathways include the breadth of experiences starting from initial interest in engineering through college and career choice. Engineering education scholars and practitioners seek to design equitable learning environments and would benefit from understanding Black youths' and families' counterstories.

Research Objectives

This project aimed to provide examples of Black familial practices that can operate as capital along youth's engineering education pathways. The findings presented in this paper detail familial practices—the ways that Black families engage and support their children's engineering interests. This research study is a response to calls for more research on how children learn skills rather than a sole focus on what children know about the world of work (Hartung et al., 2005). In this study, we

Table 1
Descriptions of parental roles observed in science, engineering, and computational thinking scholarship.

Parental role	Parental role descriptions
Engineering career mentor	Parents provide career encouragement from the inception of science and/or engineering interest until college major selection.
Engineering attitudes builder	Parents' attitude towards science and engineering (S&E) can shape their child's S&E attitude.
Achievement stimulus	The interactions/involvement between parents and their children yield positive academic achievement outcomes.
Scientific/engineering thinking guider	Parents' science and engineering knowledge informs their educational strategies.
Engineering engagement advocate	Parents seek and/or engage in engineering activities that could lead to engineering education and career choice.
Supervising/directing	The parent provides specific instructions on how to act.
Facilitation	The parent provides specific suggestions on how to think.
Co-learning	Parent and child share and learn from each other.
Student of the child	The parent acts as the student and prompts the child to lead.
Encouragement	The parent reassures and encourages the child as they work on a task.
Disengagement	The parent leaves the child to work on their own.

emphasized the role of familial characteristics such as language, social norms, social structures, and social practices in children's development (Vygotsky, 1978).

Relevant Literature

In this section, we highlight existing scholarship that sheds light on how Black families provide pre-college engineering support. We then justify the appropriateness of applying an assets-based research approach to investigate this issue.

Engineering Engagement in Black Families

Black families and children have a rightful presence in STEM and in STEM learning environments (Calabrese Barton & Tan, 2020). Scholarship in STEM education underscores the role of both parent–child conversations and family interactions as critical factors that influence the academic achievement of students (Flowers, 2015; Hughes & Shehab, 2010). Black families are valuable learning partners, and Black youths need to make connections between their meaning-making practices, which are used in everyday life, and STEM learning. Some of these practices include argumentation, narrative, visual and linguistic skillsets, imagining, metaphorical thinking, and explaining (Nasir, 2008; B. L. Wright, 2011; C. Wright, 2011). Black families, specifically parents, provide access to out-of-school-time STEM learning experiences, opportunities to make and tinker and engage in design and building, and for youth to use their imagination.

STEM practices are embedded in the everyday activities of Black parents and caregivers, who can and do serve as intellectual and educational resources (Gaskins, 2016; Jackson & Remillard, 2005; Khan & Grimm, 2020). Family interactions in informal learning environments (e.g., at home, in museums) have been linked to later academic achievement, yet the impact of culturally distinctive aspects of Black parental involvement, academic support, and conversational and teaching styles has been undervalued (Gonzalez & Wolters, 2006; Tenenbaum et al., 2005). Clark (2015) found differences among support strategies of low-income Black families with lower and higher achieving children. Some academically supportive practices of lower-income families include being resourceful, maintaining networks of resources connected to churches and community recreational programming, and protecting children from activities that could have a negative influence on their personal and academic outcomes (Gutman & McLoyd, 2000). Parental engagement that can influence STEM learning and career pathways includes advocacy for their children's education and creating opportunities for out-of-school learning (Jackson & Remillard, 2005; McCallum, 2016). Herndon and Hirt (2004) introduced a model that describes the role of families along the pathways of 10 junior and senior Black undergraduate college students, of which engineering was one of the majors represented in the sample. Specifically, the model includes eight connections between a successful student and their family and suggests that the foundation for success begins in pre-college years and is nurtured at different stages from pre-college through career attainment (Herndon & Hirt, 2004). The themes found in this research—academic encouragement, racial socialization, and family serving as motivation for success—align with other findings about the ways that provide Black pre-college engineering support, which can positively influence STEM learning and achievement (Russell & Atwater, 2005).

Counternarratives and Familial Capital in Black Engineering-Engaged Families

It is not enough to simply try to "motivate," "increase interest," or "improve the self-efficacy" of Black youth along engineering pathways. Too often Black youth and other people in marginalized groups are "blamed for their own underrepresentation in STEM" (Tucker-Raymond et al., 2018, p. 10). We need to recognize that there are systems, structures, and processes in place that need to be examined. Previous scholarship has focused on the complex and challenging issues that Black youth face in education, especially urban Black youth (Berry et al., 2011; Butler-Barnes et al., 2013; Coates, 2003; O'Connor et al., 2007; Palmer, 2011). Often Black families are viewed negatively as lacking the necessary capital to support successful engineering students. Recent engineering education scholarship focused on diversity, inclusion, and equity has recognized the importance of taking "assets-based" approaches to research (e.g., Denton et al., 2020; Gravel et al., 2021; Mejia et al., 2018; Mejia & Wilson-Lopez, 2016; Nazar et al., 2019). With an assets-based approach, we consider a youth's assets including language, culture, identity, literacy, and community resources. We interrogate the systems, structures, and processes that are in place—or that we are developing—to investigate the extent to which youth's assets are recognized and valued. Scholars have emphasized that a focus on deficiency narratives rarely offers impactful solutions, and it is important to continue to create and disseminate counternarrative scholarship (Harper, 2010). For example, Nazar et al. (2019) present a counternarrative of what it looks like for one youth to collaborate on an engineering design project to expand our understanding of how to support engineering design among youth who have historically been marginalized. Several engineering education researchers (e.g., Mejia & Wilson-Lopez, 2016; Verdín et al., 2021; Wilson-Lopez & Acosta-Feliz, 2021; Wilson-Lopez et al., 2018) ground their asset-based research in funds of knowledge, which emerged from a qualitative study of Mexican families at the intersection of home and school, including broad and diverse historically accumulated and culturally developed bodies of knowledge and skills (González et al., 2005; Moll et al., 1992). Another theory that has recently been used by engineering education researchers interested in taking assets-based approaches is community cultural wealth (CCW; Denton et al., 2020; Dika et al., 2017; Foxx, 2014; Revelo, 2015; Samuelson & Litzler, 2016; Tolbert, 2017). Yosso (2005) developed the CCW theoretical framework from the critical race theory paradigm. In CCW, Yosso (2005) posits that Communities of Color possess and utilize an array of knowledge, skills, abilities, and contacts to survive and resist macro- and micro-forms of oppression. There are at least six forms of interconnected wealth—familial, social, aspirational, navigational, linguistic, and resistant capital—that individuals from Communities of Color possess, learn, share, and leverage.

While researchers and educators recognize the importance of taking an assets-based approach to scholarship and teaching, there is a paucity of research that details the engineering-related assets of Black youth and how these assets could inform the design of engineering learning experiences. Therefore, in this paper, we focus on the engineering-related familial capital—"cultural knowledge nurtured among familia (kin) that carry a sense of community, history, memory, and cultural intuition" (Yosso, 2005, p. 79)—of Black youth. We contend that CCW exists in Black families and that family members serve as valuable learning partners and sources of familial capital for their children.

Theoretical Framework

For this research, CCW was used as a theoretical framework. In their systematic literature review, Denton et al. (2020) identified CCW as an actionable framework that engineering education scholars can use to focus on student assets rather than deficits. Denton and colleagues (2020) identified 33 STEM education publications that used CCW and presented empirical data. Their work provided several examples of engineering-relevant assets for each form of capital and a summary of the literature that highlights examples of childhood sources of capital. Of the 33 publications included in the systematic review, 24 included examples of familial capital. These 24 studies described examples of family support in encouraging persistence, showing pride in students' accomplishments, supporting STEM as a career choice, telling stories of resilience, and setting expectations for doing well in school, and respecting teachers and professors (e.g., Dika et al., 2017; Samuelson & Litzler, 2016; Tolbert, 2017). Other forms of familial capital included parents and other family members supporting the development of a strong academic work ethic, sharing of their STEM career work (e.g., Dika et al., 2017; Foxx, 2014; Samuelson & Litzler, 2016; Tolbert, 2017), providing STEM-related toys and kits (e.g., Samuelson & Litzler, 2016), and making connections to people in their professional and social networks (e.g., Tolbert, 2017). However, only two publications focused specifically on Black engineering students (Tolbert, 2017; Tolbert & Cardella, 2016). This paper directly builds upon that work. Finally, Denton and colleagues (2020) note that Yosso's (2005) definition of familial capital includes the idea of the surrounding community as another source of familial capital that has received limited attention in STEM education research. We acknowledge the importance of community and the ways that extended family (e.g., family friends who are considered "aunts" or "uncles") support Black youth and families. However, in this paper, we center on

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narratives shared by families in this current data set, which include an overwhelming focus on immediate family. This study used CCW, more specifically familial capital, to guide analysis and interpret findings.

Position Statement

Researchers' values, worldviews, backgrounds, identities, experiences, and assumptions impact research. We agree with the argument presented in Secules et al. (2021) that it is important for all researchers to reflect on and represent their positionality in their publications: "An examination of positionality can and should disrupt the notion that any of us can remove ourselves entirely from the personal and interpersonal nature of research, education, or equity" (p. 38).

Our positionalities as researchers were important to our data collection and analysis processes, including our interest in the research topic, our methodological choices, how we related to participants, and our interpretations of the data (Secules et al., 2021). DeLean Tolbert Smith is a Black woman. She has developed and facilitated K-12 STEM outreach programs. Her family—parents, siblings, "aunts," "uncles," cousins, and community members—encouraged her aspirations to pursue an engineering career like others in the family. They provided varied examples of what engineering-related careers and engineering activities could look like in everyday life. She reflected on those experiences, throughout the research process. Tamecia Jones is an American-born Black cisgender woman. She taught fifth through eighth grade and developed and implemented informal K-12 programming prior to the primary research being conducted. She is not a parent, but at the time of the interviews was the aunt of a middle school child and has served as a mentor to Black middle school youth. Monica Cardella is a white woman. Recognizing that there are dangers when white people conduct research with people of color (Milner, 2007), she is committed to working in partnership and engaging in critical reflection on what it means to do research with researchers and educators of Color as a white researcher, using resources like the questions developed by Tucker-Raymond (2020). She is currently the parent of a middle-school-aged child; although her children were younger when the data were initially collected and analyzed, she acknowledges that she often reflects on her own experiences as a parent in her research on how family interactions support engineering learning.

We did not hold any prior relationship with any of the participants in the study (either the youth or their families). In the original interviews, Tamecia Jones identified her racial/ethnic background in conversations with participants and invited families to ask questions about her background and experiences to practice interviewing her, encourage curiosity, or confirm cultural and social similarities. Interviews were held at the desired location of the participants (home, campus, local library, etc.) to increase comfort. Tamecia also invited participants to "show-and-tell" any artifacts they discussed in the interviews, in person, or via email from parents. During analysis, we examined data and conclusions and reflected on our assumptions based on our multiple identities and intersectionality as Black or White, women, parents, adult children who participated in out-of-school activities, mentors, teachers, or researchers. This influenced our interpretation and chosen language while motivating an intended balanced identification and resolution of blind spots.

Methods

We conducted a narrative inquiry using interviews of Black parents and children to investigate how family members serve as engineering learning partners. Data for this study stem from a larger three-year project investigating the informal engineering experiences of middle-school-aged youth in the Midwestern and Northeastern regions of the USA. That study's primary goal was to use social cognitive career theory to understand how informal educational activities influence students' college major choice and investigate factors that led to youth's decisions to continue to pursue or decrease participation in engineering-related activities (Cardella et al., 2014; Paulsen et al., 2015). That study aimed to identify pathways generated, obstacles, and successes that middle-school-aged youth and families experienced participating in engineering activities by following youth from the beginning to end of middle school (academic years 2012–2013, 2013–2014, and 2014–2015). From the eligible sample, 60 children were selected for inclusion in the broader study. Children were invited based on an eligibility logic model score, which included baseline criteria (entering sixth grade, reading and speaking English, and having internet access) and participation and motivation factors such as informal club memberships, taking things apart, building outside of school, and playing with engineering-related toys. Children and their families received $100 for each year of participation through eighth grade for the completion of annual surveys and interviews. Children and parent interviews and surveys included questions about self-efficacy, interest, motivation, understanding of engineering, and career aspirations. Annual parent interviews provided historical and contextual information about their children's involvement in engineering-related activities (see Appendix A for additional details about the initial study and Appendix B for sample interview questions for parents and children in years 1, 2, and 3). Thematic narratives were written that synthesized all parent and youth interviews and demographic data. These narratives were used in this new analysis.

Participants

In the original three-year study data, eight participants identified as Black or African American, and of those, two identified as female. For these eight participants, 30 youth and parent interviews occurred over three years of data collection. In this study, we specifically focus on the narratives of three families. During analysis, we found that the data from the selected families were rich with experiences, reflections, and insights that would best represent the diverse ways that familial practices were enacted across the data set. These families represented different types of schooling, including single- and two-parent households, and included the experiences of both boys and girls. Table 2 illustrates the participant information for the selected narratives (Adam, Lauren, and Phillip). Adam is the caring, smart, confident, youngest son of a suburban Midwestern middle-class family with a science teacher father and lawyer mother. His parents support him by saving household objects that he can take apart and "fix." Lauren is the creative only daughter of a middle-class single mother with a STEM bachelor's degree and resources to support Lauren's artistic interests. Lauren's mother advocates for STEM learning for all youth by serving on the technology committee at Lauren's charter school. Phillip is the artistic, video-gaming son in a blended middle-class Midwestern family. He was not confidently academic at school traditionally, but his gaming inspired him to build a high-performance gaming computer for which his parents purchased the materials. Each family is described in more detail in the findings section.

Data Collection

The second and third authors were members of a team that designed the primary study and collected the data used in this current study. Extending the previous data collection methods, the first author received the narratives generated from the larger study and the uncoded interview transcripts. The data for the parent–child data interviews constituted one unit, yielding eight total units of study, three of which are the focus of this paper.

Data Analysis

Narrative thematic analysis guided the development of counternarratives, which have been applied in both education (Solórzano & Yosso, 2002) and engineering education research studies (Mejia et al., 2018). Solórzano and Yosso (2002) define counternarrative as a "method of telling the stories of people who are often overlooked in the literature, and as a means by which to examine, critique, and counter majoritarian stories (or master narratives) composed about people of color" (p. 32). We adopt the counternarrative approach to disrupt persistent deficit narratives about the roles of Black families in engineering success and educational achievement. This narrative thematic analysis consists of (a) organization and preparation of the data, (b) obtaining a general sense of the information, (c) the coding process, (d) categories or themes, and (e) interpretation of the data (Creswell & Creswell, 2018). The research team analyzed existing data; therefore, once the data were organized the first author began attentively reading transcripts and the second author's previously written narratives to gain familiarity with the transcribed interview (Guba & Lincoln, 1994). To initiate the coding process, the first author recorded field notes, documented thoughts about potential codes, and reflected on how well the data fit within the framework. CCW enabled us to narrow our focus in the interview excerpts to identify when the participants discussed the roles of families (i.e., values, knowledge, assets, skills, support) in their engineering experiences. In the exploratory cycle of coding, the cases were analyzed using provisional codes generated from the preliminary review of the data. The initial code list contained 22 codes. Using an iterative inductive process, the second cycle of coding led to codes being revised and reduced to include codes that related to family (e.g., involved family sharing, teaching, modeling, interacting, etc.) and then placed into 14 categories. Eight themes were identified as the categories' definitions sharpened and as patterns

Table 2
Demographic information of the three youth included in this paper.

Pseudonym	Sex	Geography	School type	Grade in study	Participation	Siblings	Parent occupation
Adam	M	Suburban Midwest	Public	6	Year 1 (2012–2013)	(1) brother	Mother (lawyer), Father (scientist)
Lauren	F	Urban Midwest	Charter	6, 7	Year 1–Year 2 (2012–2014)	None	Mother (information technology)
Phillip	M	Suburban Midwest	Public	6, 7, 8	Year 1–Year 3 (2012–2015)	(4) 2 brothers and 2 sisters	Mother (realtor), Father (unknown)

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Table 3
Example of the stages of narrative thematic analysis performed on Lauren's transcripts.

Transcript excerpt	Initial code	Corresponding category	Corresponding theme
Interviewer: Okay. Does she draw too? Lauren's Mother: Yeah. She's a very good artist. She's had that gift since she was little. Smaller I should say. She's only twelve. I saw that in her very very early. She's not afraid of IT, she's installing software on her laptop. She's had a laptop since she was four; like a real laptop not like a Barbie one like a real laptop. You know what I mean. So she has a very high aptitude for using technology. She likes using apps.	Mother provided resources activities that will develop daughters technological interests	Parents providing resources to support STEM engagement	Familial capital [P2] Providing/engaging in television shows and virtual engineering activities [P5] Parents supporting STEM learning experiences and STEM activities

surfaced. The themes were later identified as the eight practices described in the findings section. Table 3 provides an example excerpt and the stages of analysis in this study.

In the final stage of the narrative thematic analysis, the data were interpreted through counternarrative storying. Solórzano and Yosso (2002) identified three different types of counternarratives: personal stories, other people's stories, and composite stories. In this paper, we used the data to tell our participants' stories and describe Black children's engineering experiences with a focus on the roles and impact of various family members. Following Polkinghorne's (1995) analysis of the narrative method, the analyzed data were retold as detailed narratives, which were written using a third-person storytelling approach, which enables high narrator reliability and high authorial distance (Walther et al., 2013). We adopted an "interpretation of faith" (Josselson, 2004), meaning that we operated from the belief that the participants are telling true and meaningful stories. The authors synthesized critical observations related to the participants' familial practices and their influence (Miles et al., 2014). Likewise, the findings are presented in narrative format with selected interview excerpts that support the key findings of this work. In the findings sections, the excerpts are labeled according to the familial practice/theme they align with.

Trustworthiness

The authors established the trustworthiness of the findings and the analytical approach. Throughout the process, each individual on the research team closely reviewed all available data. Author one was primarily responsible for analysis; however, segments of the interview data were coded by authors two and three. All differences were resolved through discussion and the meanings of the codes were refined. Through iterative coding conversations, final decisions were made on the analytical approach, the framework description, the emergent categories, and the application of the framework to the data.

Findings

An analysis of the data revealed eight practices that families engaged in to support Black children in engineering interests. The analysis of these practices provided examples of how the family members and the children in this study utilized familial capital as described in CCW. Our analysis uncovered the influential role of parental support of educational achievement and engineering interests in their children's developing engineering skills. The findings underscore the critical influence of families on the children in this study. Whereas previous work highlights organizational, institutional, and formal educational support, the findings presented in this study contribute descriptive instances of familial practices from both the parents' and the children's perspectives as examples of Black familial capital in action. Table 4 includes the familial practices and descriptions of how each practice was enacted.

The authors present three narratives that represent the overarching themes and practices of the Black families in this study. At the end of each narrative, we synthesize the relevant aspects of familial cultural capital and throughout the summary paragraphs we indicate with [P#] which practices emerged in the narrative data.

Entire Family Invested in Engineering-Related Interests and Development

Adam participated in the first year of the three-year research study. At the time of the study, Adam lived in a suburban Midwest community with his parents and one older brother. He was a sixth grade student in a public school. Both of his

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Table 4
Descriptions of Black families' practices that support engineering interest.

Familial practices (P)		Descriptions of familial practices
P1	Finding and/or participating in structured engineering clubs, teams, and activities	This practice includes parents finding and children participating in afterschool programs, extracurricular activities that are sponsored by local industries, and well-designed engineering activities.
P2	Providing and/or engaging in television shows and virtual engineering activities	In this practice, children and parents reported experiences with playing engineering-related video, computer, and internet games; watching engineering television shows; and visiting engineering websites.
P3	Making do: using available resources to solve a problem	This practice is characterized by innovative moments in which children use available resources to complete a design or task and/or family members modeling/encouraging this behavior.
P4	Making connections between STEM and non-STEM settings	This practice relates to family members and children transferring STEM knowledge across contexts to identify and solve problems.
P5	Parents supporting STEM learning experiences and STEM activities	Family members engaged in this practice by providing resources and materials and cultivating a culture that encouraged engagement in engineering experiences.
P6	Children preparing for desired careers	Children engaged in this practice by performing STEM and non-STEM career preparation and seeking activities. Parents discuss support and encouragement for career preparation.
P7	Family conversations and advice about education and careers	This practice includes family conversations and expectations about careers, education, and advice they gave about navigating education and career success.
P8	Designing, building, and creating with family members, friends, and classmates	While engaging in this practice, these children reported collaborating with family members, friends, and classmates in various settings.

parents had earned advanced degrees and his father worked in a STEM field. Adam's mother believes he is "smart" and sometimes has to encourage him to think about his creative decisions critically. She explained, "[My] son is smart. He knows he's smart. I have to sometimes tell him to back up and rethink because he's so sure that he has [all the] answers." Adam is very resourceful. He often has ideas and uses various objects from around and outside the house. He reflected, "Someone else says it's a problem. So I try and fix it anyway I can." Some projects that he has completed include origami men made from diverse materials, a re-engineered television remote control to be powered by solar energy, and a giant roller coaster with his bunk bed. He also works with his brother on many of his tinkering projects around the house. Adam reflected on one experience working on a project with his brother:

> Well before I got my rollercoaster set we made—when my brother and I had bunk beds we made a giant roller coaster out of paper with duct tape on the railings so it did some cool things like go around the cylinder that's pretty big. So I think we had one jump—I'm not quite sure and we made it turn directions and all sorts of things.

Adam's parents support his resourcefulness by providing old household tools and encouraging him and his brother to use those for their projects. His mother shared, "We used to even hold on to things you know things that—and suggests that they—just take these apart to see what's in there." They also taught their children which objects were off limits, but they did not prevent them from tinkering. On this, his mother reflected on exchanges she has with him about materials:

> "Sweetheart you can't take all those sticks to the house. You know we're not walking all the way home with those mini sticks." Because again [he says] "I got this idea of something that I'm going to build with…" It's not always a mechanical something.

Adam's inquisitive nature enables him to develop problem-solving behaviors. His mother calls him "that cardboard box kid," which alludes to his ability to use any materials available to him to develop solutions to problems he has identified. His mother considers his inquisitive nature and flexibility in problem-solving "a gift that needs to be developed." His family invests in family activities including one-on-one quiet time, travel, spades, hiking, fishing, and running. Though she was hesitant to join him in his engineering work, Adam's mother was very observant of his engineering interests and provided opportunities for him to engage in engineering activities. She recalled her experience creating a technology party for him:

> He had a—his last birthday party was like a technology party and different stations were set up in the house and it was a competition and then they moved from station to station and one of the trophy that they—big brother facilitated.

As he spends time with each family member, he learns about their interests and this informs his ideas and how he does his engineering work. Adam recalled how his interests in engineering developed:

> I was watching a lot of things on YouTube. Like how they made the kind of things and I tried making it and then I make my own stuff and then I'd slowly wanted to be that and it's also from—and I think—it's partly my dad because he's a scientist.

Through these family moments, he sees a connection between engineering, science, his interests in social studies, politics, the economy, and social problems. These moments allow his family to observe and develop a depth of understanding about the things that interest Adam and in turn learn about their careers and interests. The family can then provide him with experiences, materials, and resources that support his interests.

Summary of Adam's Experiences

It was obvious that Adam benefited from his family's commitment to spending quality time together. For this family, quality time could include reading together for a specific time, taking a family vacation, discussing career opportunities and expectations, and working together on engineering-related projects. Each member—mother, father, and brother—had some influence on Adam's engineering experiences and interests. Adam's parents allowed him to access the internet and play video games at home, which inspired Adam's creative ideas [P2]. In addition to providing access to these resources, Adam's parents encouraged him to use materials found around the house while also placing limits on what was acceptable to disassemble and bring into the house. This promoted engineering habits such as working within constraints, prototyping, and resourcefulness [P3]. Adam's mother identified disposable household items that he potentially could use during his idea generation and building sessions [P5]. His family frequently discussed career options and did not pressure Adam or his brother to explore engineering but did expose them to their career paths [P7]. Adam's brother was one of the most active family members when it came to building, tinkering, and creating with Adam. He often exhibited patience while he worked with his little brother on his creative ideas [P8].

Single Mother Leveraging Her Profession to Provide Access to STEM Resources

Lauren participated in the first and second years of the three-year research study. At the time of the study, she lived in a single-parent household in an urban Midwest community with her mother. She was a sixth (and then seventh) grade student attending a charter school. Lauren's mother earned a STEM bachelor's degree and worked in the information technology field. Lauren likes baking, hanging out with her friends, and singing and performing in a children's choir. Lauren also enjoys developing herself artistically, expressing herself through music and drama, and creating art. Though she has not explicitly expressed interest in engineering, she has engineering-related interests such as designing, building, and creating, which allow her to use her creativity and artistic skill. Lauren describes herself as one who "like[s] art and books and everything more like artsy. And [she] also like[s] science because [she] thinks it's really cool."

Lauren's mother, who was an information technology (IT) professional, was very active in providing Lauren with the resources she needed in and out of school. Her mother reflected, "You know she's got the tablet that she can draw on. I mean I'm doing this on purpose because that's my career. I've been in IT all my career so…Unfortunately, this school does not reinforce it at all." She served on the technology committee at Lauren's school until Lauren's seventh grade year. In this way, she encouraged Lauren to develop her creative and artsy skills and concurrently provided opportunities for her daughter to learn and develop skills related to engineering and technology. Her mother described two of her technology experiences:

> She did digital movie making videos using Apple iOS. It was a weeklong workshop. And they were taught digital photography and then video editing…And we did that—at our tech camp, we did video editing we did movie editing.

Lauren joined an international program called Ultimate Problem Solvers where she engaged in designing, building, creating, and debating. The problem-solving debate program met weekly in the summer and during the school year to learn about and debate topics such as space program funding. Lauren recalled that that "[Ultimate Problem Solvers program] gave us scenarios from the future and we were supposed to figure out how we can keep them from happening." She has also participated in other engineering and technology camps. A large university in her state hosted an engineering camp, but it was challenging for Lauren because while she has engineering skills, the material was not interesting to her.

Lauren also played with engineering-related computer games (e.g., SimCity) and video games, designed apps, and visited relevant websites. Her mother commented, "She's doing it on her own. I'm just giving her the tools she's asking for. She wants to get a bigger tablet so she can do…more complicated drawings." Lauren worked to understand the types of technology she needed to make her designs. As an IT professional, Lauren's mother felt the burden of ensuring that her daughter had the resources she needed to develop design, creativity, and building skills. She has provided these resources since Lauren was four years old.

In the sixth and seventh grades, Lauren played with SimCity 4, which was the latest version at the time of the interviews. This game appealed to Lauren's creativity and she was able to work for hours building and designing cities. Lauren also enjoyed spending time with her friends, and the collaboration function of the game gave her that freedom.

Although Lauren had many engineering and technology experiences, she "hasn't found anything like a class that Lauren could take to teach her coding so that she could actually start to build and start learning the fundamentals of iOS. Not for that age group. It's most of the time senior high school and higher…when you find classes like that." In the sixth grade, Lauren expressed interest in iOS application design, but many of the activities are "very introductory." Her mother hoped that in high school she would learn more coding skills. She observed:

> [Lauren's] not afraid of IT. She is installing software on her laptop. She has had a laptop since she was four; like a real laptop not like a Barbie one like a real laptop. You know what I mean? So she has a very high aptitude for using technology.

Lauren and her mother had conversations about her varied interests and career pathways. Although Lauren primarily wanted a career in the arts, her mother observed her creative talents and technological interests and encouraged Lauren to pursue careers in animation and architecture. She described a career conversation, "Her software is building cities and neighborhoods and houses. I tell her she should be an architect, but she doesn't think that's what she wants to be, but she has a knack for that." By the seventh grade, Lauren was no longer interested in an entertainment career, and at the final interview, she had no new career ideas. She asked for more information about college programs. Although her mother recalled talking with her about different career paths, Lauren only disclosed career conversations with a teacher.

Summary of Lauren's Experiences

Lauren's mother was intentional about the ways that she leveraged her knowledge of STEM, her profession, and observations of Lauren's interests to provide her with resources and experiences that she needed. Her mother even acted as an advocate and joined the school's technology committee; in this way, she ensured that the school had current technology resources for all the students. Though Lauren had an older stepsister who lived outside of the home, Lauren and her mother were the focus of their interview responses. Lauren's mother ensured that Lauren participated in a digital movie-making workshop at an Apple store and participated in Future Problem Solvers, where she learned about creativity and problem-solving strategies [P1, P4]. Lauren's mother provided her with current technology such as a laptop and SimCity software which Lauren used to collaborate with friends [P2]. Not only did Lauren's mother support her out-of-school-time STEM activities but she also joined the school's technology committee to ensure that all the students had the right tools in the classroom [P5]. Lauren and her mother have career conversations, which is evidenced by Lauren's awareness of her mother's IT profession. Based on their conversations and her mother's observations, she encouraged Lauren to consider specific career pathways [P7]. In her mother's role as the chair of the technology committee, she launched a school technology camp that she and Lauren participated in together [P8].

Supportive Parents Who Emphasize Academic Achievement over Design Experiences

Phillip participated in all three years of the research study. During his participation, Phillip lived in a suburban Midwest community with his parents and four siblings (two sisters, two brothers, and a stepsister in college). His mother completed some college and had a career as a realtor. His father graduated from college and his profession was not shared. Phillip's mother and father observed that he was a "hands-on" learner who used accessible materials, such as folding his father's ties into origami men. They observed that "he's kind of a loner. He does things on his own a lot or with [his brother]."

Phillip engaged in designing, building, and creating at home, virtually, and by using his imagination. His parents considered him "creative and artistic" at home and his mother noted that:

> [Phillip] likes to go in his room and like I said…you go on up right now and you'd find a floor full of those ties that I didn't even know that he had and he's up there building with the Legos and the ties.

Origami structures, miniature cities, and ninja stars are examples of hands-on projects that Phillip was able to imagine and create with little external support. He recalled, "one time at my grandma's house I built a whole thing of paper like a whole land with buildings and people." Phillip would ask his brothers and sisters for help with larger projects. In the eighth grade, Phillip spent time with one of his older brothers and three very close cousins and learned how to build a computer. About this experience, Phillip shared:

> I just, I wanted one [laptop] of my own and I like playing games on it so I wanted something that would like to be better at playing games then like a little laptop kind of thing…I planned it and then I asked for like all the parts for Christmas…I had help with my cousin…We built it together.

He always sought out ways to improve his computer and was very proud of his work with his cousins and brother. Phillip's mother explained, "His cousin is really into building, and so I think that's kind of inspired him to want to do, to build his own [laptop]." His parents did not work with him during his computer building, design, and gaming but they paid close attention to his interests and provided him with the materials he needed to support and meet his goals.

Phillip relied heavily on his imagination to build, design, and create. He often used phrases such as getting ideas "out of his head" or from "his mind." He was innovative and used unexpected materials to accomplish the goals he had for the design. When asked how he knew to use ties to make origami people, he responded "I just...I didn't know at first but like when it needed to be like stable and stuff I just thought of strings in my head and tying stuff." His mother reiterated that "he's very good at making things out of like I said of nothing." His father acknowledged Phillip's creativity:

> I mean he's creative. He's artistic. It's obviously there—The mechanical side of it—I think is an underlying part of it…but I think it starts out with an artistic avenue from it. But then there's some technical side to it because I think that's underlying in how he manipulates materials or what he does with the certain objects.

In the sixth grade, Phillip's parents sought out ways to support his design interests specifically by giving him art supplies and providing verbal affirmation and praise when he showed them his work. His mother shared, "I actually enrolled him in an art class…and he's learning how to draw… So he goes there once a week. That's me trying to get him out of the video games because he's not doing very well with his grades either." Phillip's parents make it clear that they prioritized his educational success over his creative interests and hobbies—even though they have supported his design interests since he was four years old. They explained, "…but right now his creativity is certainly important but as like his education is…first priority." In the seventh grade, year 2, Phillip's parents enrolled him in a local art program to support his creative interests and hopefully to re-engage him in hobbies beyond video games.

While Phillip's motivation and interest in school declined, his interests in engineering activities (i.e., designing, building, and creating) continued to evolve. His evolved interests were most prominent through his computer hardware, computer app design, and video gameplay. His mother observed:

> He has a strong interest in video games; in Minecraft even and all these other games. That's pretty much all he had any interest in. He still builds things and makes little men out of characters and stuff, and draws, and stuff like that but the video game thing has pretty much taken over a lot this past year, unfortunately, so I'm trying to nip that in the bud.

In the sixth grade, he stated that he was considering a job in a math-related field and was considering a job in video game design. However, by the seventh grade, he was no longer interested in math, but he still enjoyed video games and also wanted to create his own. He hoped to have a career in video game design; however, during the study Phillip's parents grew suspicious that increased time with video games and apps were the source of his academic disinterest.

In contrast to his "laid back" approach to school, Phillip's mother noticed that he was motivated during his design and creativity time and lamented, "I feel bad because I feel like this past year I haven't been feeding it, trying to help him, encouraging it." His mother expressed that his creative abilities were a gift that if not "fine-tuned" could lead him to a career pathway that does not provide satisfaction. In year 3 of the study, Phillip rarely came home to draw after school and more typically came home and played video games. His mother believed that a career in design would fit her son well but explained that they had not yet begun career conversations with him. Phillip's parents planned to have career conversations in the coming years as he matriculated through high school.

Summary of Phillip's Experiences

Phillip's family was supportive of his hobbies and provided him with the resources he wanted and needed. However, they believed that some of his interests, namely video gaming, were in direct conflict with his academic success. Parental support occurred through behaviors such as encouragement to explore, enrollment in art programs, verbalized affirmations, and praise, guidance, and supplying tools and resources. Throughout the three years of the study, Phillip's design, creativity, and building practices took different forms but his interest in video games was consistent for each year of the research study. Ultimately, his interest in video and computer games generated an interest in the technology behind video games and computers. Though Phillip was a loner, an older brother and some close-in-age cousins were some of his family partners in his designing, building, and creating. Phillip had waxing and waning interest in art drawing and sketching, so his parents sought out engineering skill-building programs such as the Art Club [P1]. His parents, hesitantly, allowed Phillip to play computer games such as Minecraft and other video games. Access to these activities spurred his later interest in computer hardware and computer design [P2]. Phillip was resourceful and enjoyed building with easily accessible and sometimes unexpected materials such as his father's ties and paper [P3]. Phillip's father observed that Phillip's imagination allowed him to make connections across settings and experiences [P4]. Though Phillip's parents did not work with him during his engineering-related activities, they did support his interests by providing equipment that he would need for his innovations [P5]. Phillip demonstrated preparation for a career as a video game designer by downloading an app to help him design games and learning how to build a computer to improve the quality of his video gaming [P6]. Throughout the study, his parents supported his artistic and building hobbies in different ways, but they were concerned that his video gaming would distract him from academic success. They communicated their expectations about his academic performance. They planned to have more specific career conversations when he entered high school [P7]. Phillip's older siblings and his cousins served as his primary partners in design, building, and creating [P8].

This narrative inquiry further extends the CCW theory with specific emphasis on operationalizing the familial capital and the related practices of Black families in STEM. Vygotsky's social-development theories stress that adults transmit cultural knowledge, language norms, and practices that influence children's traits, skills, and beliefs (Vygotsky, 1978). However, in this study, we see that both adults and children in families were responsible for transmitting knowledge that influenced a child's skill. Consider Phillip learning how to build a computer from and with his older brother and cousins. We observed that parents, grandparents, siblings, and cousins served as critical learning partners in the children's STEM experiences. Parents' access to resources included time, money, their STEM professional networks, and knowledge of engineering programming and activities for their children. Family practices could influence not only how a child engages in engineering activities but also the child's engineering interests and learning.

Discussion

CCW: Familial Capital Provided by Eight Practices with Diverse Manifestations

In this study, we investigated the different ways that Black families serve as valuable engineering learning partners for their children and as sources of familial capital. The family–child interactions, conversations, and support of their children's interests provide evidence-critical insight into the diverse roles that family members can play in supporting engineering interests. We sought to answer the question*: In what ways do Black families support their middle school children's engineering interests?* Eight practices emerged across the data set and manifested across the cases in slightly different ways (Table 4).

As expected, the behaviors that the parents and children discussed aligned with familial capital and with existing scholarship that documents how Black families provide support. Building upon prior work (Dorie et al., 2014; Ohland et al., 2019; Yun et al., 2010), Black parental and family-member involvement highlighted in this study spanned across multiple roles. Even parents who were hesitant about the academic outcomes of prioritizing creative work over academic achievement acted as engineering engagement advocates by providing tools, activities, and resources that the children could use to develop engineering skills and interests.

Adam and his parents and siblings invested and engaged in Adam's engineering-related interests and development. Father, mother, and brother observed Adam and found ways to directly support and encourage his interest. His parents acted as engineering career mentors, engineering attitudes builders, supervisors/directors, and achievement stimuli (Yun et al., 2010). His brother served the role of encourager and facilitator when they worked together on engineering tasks (Ohland et al., 2019). Cohesion and strong family bonds not only have a positive influence on college-going practices for Black and Latino boys (Carey, 2016), but strong family support of science and mathematics interests also positively influences academic achievement (Smith & Hausafus, 1998).

Lauren benefits from her single mother leveraging her profession to provide access to STEM resources and experiences. She maintains her interest in virtual design projects, creativity, and problem-solving competitions without discarding her interest in music and drama. Her mother served as an engineering career mentor, engineering attitudes builder, achievement stimulus, and thinking guider (Yun et al., 2010). She was also an engagement advocate for her daughters and her schoolmates (Dorie et al., 2014). Cheng et al. (2017) explored the effect of parent role modeling and parent growth mindset on their children's STEM outcomes and found that a parent's growth mindset benefits girls' STEM outcomes more strongly than boys'. Additionally, a girl whose mother works in a STEM field will more likely pursue a STEM pathway and have increased participation in STEM activities (Cheng et al., 2017; Jacobs & Bleeker, 2004).

Phillip and his family can be characterized as a family whose parents encourage engineering exploration, who are observant of their son's engineering interests yet hesitant to fully encourage these activities as they believe he may be distracted from academic success. His parents were not hands-on, and his father demonstrated disengagement from Phillip's engineering work. Though the parents appeared skeptical, they still worked as advocates. As they supported his interests, they also made clear their expectations for his success, and Phillip's engineering-related interests and skills increased, which is evidence of a form of the academic achievement stimulus role.

Herndon and Hirt (2004) argue that particularly during the pre-college stage, families lay the foundation for future academic success through their influence (encouragement; financial, moral, and social support), which includes expectations for high academic achievement and seeking out enrichment programs and activities. Similarly, Russell and Atwater (2005) found that their participants' parents and teachers played key roles in the Black students' success in science through their high educational expectations, encouragement, and career acceptance. The findings from this current study build upon this scholarship. We now observe similar parental forms of support in the data of middle-school-aged youth who demonstrate engineering-related interests. These findings also extend the Dorie et al. (2014) parental role of "engineering engagement advocate" to include Black parents who faced obstacles finding existing engineering activities, innovated opportunities, and provided non-traditional resources that encourage engineering interest.

The findings from these three narratives build upon Gaskins's (2016) museum study and provide insights into cultural models of family learning and cultural patterns of belief about engineering learning and parental interaction. Gaskins (2016) observed cultural differences in family learning of White, Black, and Latine families in a museum setting. Specifically, Black parents were less likely to join in play that did not require directed instruction. Since directed instruction often requires some STEM content knowledge, a parent without this content knowledge may find other ways to support STEM learning without engaging directly in STEM play. The parents knew their children's interests and found ways to encourage engineering exploration and learning. Consider Adam and Phillip. Their parents provided encouragement, resources, and support despite their hesitancy to participate directly. On the other hand, Lauren's mother had extensive STEM experience and knowledge; she actively extended her daughter's STEM learning. She facilitated and advocated for Lauren's STEM interests by providing technology, enrolling her in STEM camps, and through conversations with Lauren about her STEM profession.

Previous scholarship focused on the diverse roles that parents play in supporting their children's STEM interests. In addition to supportive roles, our findings focus on the tools, resources, and practices that Black parents and other family members employ to support their children. An additional contribution of this study is the research design. Our use of data from the larger study created an opportunity to advance the body of knowledge in an underexplored area of research.

Limitations

For this study, we conducted a secondary analysis of existing data. Having access to data from the broader study benefits the advancement of work in an underexplored area of study. However, the data were not curated specifically to address the research objectives, meaning that although the families' experiences, circumstances, response, and behaviors suggest alignment with CCW, the interview protocol did not probe specifically for aspects of capital or the participants' response to racism and opposition (see Appendix B for interview questions). It is important that when engaging in critical research, the work questions power, privilege, and oppression. However, the study protocols from which the data originated did not explicitly solicit such experiences or responses. Therefore, those important topics did not explicitly emerge from the existing interview data. An interview protocol more aligned with the goals of this study would include questions that could generate answers that provide insight into the role of power, privilege, and oppression.

We were, however, able to adopt a counternarrative approach through the interpretation and presentation of the narratives in the findings. We do not generalize these findings to describe supportive practices of all Black families. Rather, the findings provide examples of counternarratives, which challenge dominant deficient narratives of Black families and their influence and center narratives of influential support and encouragement. Future work can build upon these counternarratives and deepen our understanding of Black families' roles in engineering education.

Implications

The practices described in this paper highlight the contributions of Black families to the engineering exploration of middle-school-aged children. The counternarratives in this paper disrupt positioning of Black families as resource-deficient and not engaged. We observed that parents have a central role in family engineering learning. They provided support in various ways and to various extents.

Practitioners

Parents expressed challenges finding appropriate programing and often either created engineering experiences or found ways to support learning by providing tools at home. Some parents also had limited STEM knowledge. We also observed how siblings and cousins acted as engineering learning partners. A potential implication of these findings is that practitioners and designers of family STEM engagement programs should pay attention to families' routines and culture and consider the accessibility of the program and the content (Khan & Grimm, 2020). This could include working with families to design programs that meet their needs.

Parents

Herndon and Hirt (2004) argue that the family is a conduit of educational success and achievement (p. 491). We observed how parents expressed their expectations for success and achievement. A potential implication for these findings is that parents with STEM backgrounds can leverage their backgrounds and networks to provide engaging STEM experiences for their children and their children's peers. In this way, they act as career mentors, STEM thinking guiders, and advocates. Parents without STEM backgrounds can positively shape their child's STEM attitude by (1) demonstrating a positive attitude towards STEM and (2) working as an advocate who seeks out opportunities and provides resources and encouragement.

Researchers

The rich and varied ways that Black families support engineering learning suggest two implications for future research. First, more research is needed to understand the various roles of Black family members who support engineering. Our findings highlighted the central role of parents and provided insights into the involvement of other family members. We can conclude that a study specifically designed to explore Black families in engineering might uncover how other families' members act as learning partners. The data were collected prior to the COVID-19 era. Since then, more families have become active learning partners with formal and informal curricula. Scholars should explore how family interactions and working from home influenced STEM learning outcomes and interests.

Conclusions

We recognize the powerful ways that Black families support engineering learning. We hope that parents will be empowered as advocates so that the institutions that serve their children will offer accessible and appropriate engineering experiences. We are confident that families engage in additional practices that did not emerge in this study, and we are excited to learn more about these practices with future research.

This work advances a resource-rich understanding of the impact of Black families in engineering education. We build upon existing scholarship that disrupts deficit narratives about the roles of Black families in engineering success. The practices illuminated in this study can help educators, scholars, and practitioners understand Black cultural models of support and learning. These practices must be elevated within the engineering culture so that support and inclusion of Black cultural models of learning can be improved. Essentially, we hope this work will prompt the engineering community to normalize these practices as engineering capital and redefine engineering traits to include Black families' CCW and practices.

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References

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

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

Berry, R. Q., III, Thunder, K., & McClain, O. L. (2011). Counter narratives: Examining the mathematics and racial identities of Black boys who are successful with school mathematics. *Journal of African American Males in Education*, *2*(1), 10–23.

Butler-Barnes, S., Chavous, T., Hurd, N., & Varner, F. (2013). African American adolescents' academic persistence: A strengths-based approach. *Journal of Youth and Adolescence*, *42*(9), 1443–1458. https://doi.org/10.1007/s10964-013-9962-0

Calabrese Barton, A., & Tan, E. (2020). Beyond equity as inclusion: A framework of "rightful presence" for guiding justice-oriented studies in teaching and learning. *Educational Researcher*, *49* (6), 433–440. https://doi.org/10.3102/0002831212458142

Cardella, M. E., Reid, K., Hynes, M., Lee, W. C., & Knight, D. B. (2019). Promoting the participation of elementary school African Americans, Hispanics, and girls in STEM by expanding summer engineering experiences. *126th Annual Conference of the American Society for Engineering Education*, Tampa, FL. https://doi.org/10.18260/1-2--32305

Cardella, M. E., Wolsky, M., Paulsen, C. A., & Jones, T. R. (2014). Informal pathways to engineering: Preliminary findings. *Proceedings of the 2014 ASEE Annual Conference & Exposition*, Indianapolis, IN. https://doi.org/10.18260/1-2--20638

Carey, R. L. (2016). "Keep that in mind… You're gonna go to college": Family influence on the college going processes of Black and Latino high school boys. *Urban Review*, *48*(5), 718–742. https://doi.org/10.1007/s11256-016-0375-8

Cheng, A., Koptic, K., & Zamorro, G. (2017). Can parents' growth mindset and role modelling address STEM gender gaps? In Vol. EDRE Working Paper 2017-07. University of Arkansas: Department of Education Reform.

Clark, R. M. (2015). *Family life and school achievement: Why poor Black children succeed or fail*. University of Chicago Press.

Coates, J. (2003). Frontmatter. In *Men talk: Stories in the making of masculinities* (pp. i–xii). Blackwell Publishing. https://doi.org/10.1002/9780470755617.fmatter

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Denton, M., Borrego, M., & Boklage, A. (2020). Community cultural wealth in science, technology, engineering, and mathematics education: A systematic review. *Journal of Engineering Education*, *109*(3), 556–580. https://doi.org/10.1002/jee.20322

Detroit Area Pre-College Engineering Program. (2012). *DAPCEP*. Retrieved April 28, 2013 from http://www.dapcep.org/

Dika, S. L., Pando, M. A., Tempest, B. Q., & Allen, M. E. (2017). Examining the cultural wealth of underrepresented minority engineering persisters. *Journal of Professional Issues in Engineering Education and Practice*, *144*(2), 1–9. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000358

Dorie, B. L., Jones, T., Pollock, M., & Cardella, M. (2014). Parents as critical influence: Insights from five different studies. *American Society for Engineering Education Annual Conference & Exposition*. https://doi.org/10.18260/1-2--22901

Fletcher, T. L. (2017). *Outcomes for female students within a summer engineering program: Single-sex versus coeducation*. Purdue University.

Flowers, A. M., III. (2015). The family factor: The establishment of positive academic identity for Black males engineering majors. *Western Journal of Black Studies*, *39*(1), 64–75.

Foxx, K. A. (2014). *A cultural wealth perspective on success and persistence in engineering for Black and Latino students*: *Exploring interactions with faculty and other institutional agents* [Unpublished doctoral dissertation]. The University of North Carolina.

Gaskins, S. (2016). Children's learning in museums with their families. *25th International museology and rescue excavation symposium.*

Gibbs, K. (2014). *Diversity in STEM: What it is and why it matters*. Scientific American Blog Network. blogs.scientificamerican.com/voices/diversity-in-stem-what-it-is-and-why-it-matters/

Gonzalez, A.-L., & Wolters, C. A. (2006). The relation between perceived parenting practices and achievement motivation in mathematics. *Journal of Research in Childhood Education*, *21*(2), 203–217. https://doi.org/10.1080/02568540609594589

González, N., Moll, L. C., & Amanti, C. (2005). *Funds of knowledge: Theorizing practice in households, communities, and classrooms*. L. Erlbaum Associates.

Gravel, B. E., Tucker-Raymond, E., Wagh, A., Klimczak, S., & Wilson, N. (2021). More than mechanisms: Shifting ideologies for asset-based learning in engineering education. *Journal of Pre-College Engineering Education Research (J-PEER)*, *11*(1). https://doi.org/10.7771/2157-9288.1286

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105–117). SAGE.

Gutman, L. M., & McLoyd, V. C. (2000). Parents' management of their children's education within the home, at school, and in the community: An examination of African-American families living in poverty. *Urban Review*, *32*(1), 1–24. https://doi.org/10.1023/A:1005112300726

Harper, S. R. (2010). An anti-deficit achievement framework for research on students of color in STEM. *New Directions for Institutional Research*, *2010*(148), 63–74. https://doi.org/10.1002/ir.362

Hartung, P. J., Porfeli, E. J., & Vondracek, F. W. (2005). Child vocational development: A review and reconsideration. *Journal of Vocational Behavior*, *66*, 385–419. https://doi.org/10.1016/j.jvb.2004.05.006

Herndon, M. K., & Hirt, J. B. (2004). Black students and their families: What leads to success in college. *Journal of Black Studies*, *34*(4), 489–513. https://www.jstor.org/stable/3180892

Hong, L., & Page, S. E. (2004). *Groups of diverse problem solvers can outperform groups of high-ability problem solvers*. National Academy of Sciences.

Hughes, Q., & Shehab, R. (2010). What they say matters: Parental impact on pre-college academic identity of successful African American engineering students. *ASEE Annual Conference & Exposition*, Louisville, KY. https://doi.org/10.18260/1-2--16400

Hynes, M., & Maxey, K. (2018). Investigating the fit between students' personal interests and their perceptions of engineering in a National Society of Black Engineers (NSBE) pre-college summer workshop (fundamental research). *American Society for Engineering Education Annual Conference and Exposition*, Salt Lake City, UT. https://doi.org/10.18260/1-2--30727

Jackson, K., & Remillard, J. (2005). Rethinking parent involvement: African American mothers construct their roles in the mathematics education of their children. *School Community Journal*, *15*(1), 51–73. https://repository.upenn.edu/gse_pubs/11

Jacobs, J. E., & Bleeker, M. M. (2004). Girls' and boys' developing interests in math and science: Do parents matter? *New Directions for Child and Adolescent Development*, *106*, 5–21. https://doi.org/10.1002/cd.113

Josselson, R. (2004). The hermeneutics of faith and the hermeneutics of suspicion. *Narrative Inquiry 14*(1), 1–28. https://doi.org/https://doi.org/10.1075/ni.14.1.01jos

Khan, T., & Grimm, S. B. (2020). Re-imagining the role of families as equal partners in STEM learning. *Connected Science Learning*, *2*(4). https://www.nsta.org/connected-science-learning/connected-science-learning-october-december-2020/re-imagining-role

Martin, L., & Wendell, K. B. (2021). Reflections on asset-based pre-college engineering education to promote equity: An introduction to the special issue. *Journal of Pre-College Engineering Education Research (J-PEER)*, *11*(1). https://doi.org/10.7771/2157-9288.1325

McCallum, C. M. (2016). "Mom made me do it": The role of family in African Americans' decisions to enroll in doctoral education. *Journal of Diversity in Higher Education*, *9*(1), 50–63. https://doi.org/10.1037/a0039158

Mejia, J. A., Revelo, R. A., & Villanueva, I. (2018). Critical theoretical frameworks in engineering education: An anti-deficit and liberative approach. *Education Sciences*, *8*(158), 1–13. https://doi.org/10.3390/educsci8040158

Mejia, J. A., & Wilson-Lopez, A. (2016). Sociocultural analysis of engineering design: Latino high school students' funds of knowledge and implications for culturally responsive engineering education. In *Qualitative research in STEM: Studies of equity, access, and innovation* (pp. 60–82). Routledge Publishing.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis*. SAGE.

Milner, H. R., IV. (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

Moll, L., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory Into Practice*, *31*(2), 132–141. https://doi.org/10.1080/00405849209543534

Nasir, N. S. (2005). Individual cognitive structuring and the sociocultural context: Strategy shifts in the game of dominoes. *Journal of the Learning Sciences*, *14*(1), 5–34. https://doi.org/10.1207/s15327809jls1401_2

Nasir, N. S. (2008). Everyday pedagogy: Lessons from basketball, track, and dominoes. *Phi Delta Kappan*, *89*(7), 529–533. https://doi.org/doi:10.1177/003172170808900717

National Academies of Sciences, Engineering, and Medicine. (2019). Closing the gap and advancing the nation's STEM workforce. In *Minority serving institutions: America's underutilized resource for strengthening the STEM workforce*. The National Academies Press. https://doi.org/10.17226/25257

National Center for Science and Engineering Statistics. (2021). *Women, minorities, and persons with disabilities in science and engineering*.

Nazar, C. R., Barton, A. C., Morris, C., & Tan, E. (2019). Critically engaging engineering in place by localizing counternarratives in engineering design. *Science Education*, *103*, 638–664. https://doi.org/10.1002/sce.21500

O'Connor, C., Lewis, A., & Mueller, J. (2007). Research "Black" educational experiences and outcomes: Theoretical and methodological implications. *Educational Researcher*, *36*(9), 541–552. https://doi.org/10.3102/0013189X07312661

Ohland, C., Ehsan, H., & Cardella, M. E. (2019). Parental influence on children's computational thinking in an informal setting (fundamental research). *126th Annual Conference of the American Society for Engineering Education*, Tampa, FL. https://doi.org/10.18260/1-2--33157

Palmer, R. T. (2011). *Black men in college: Implications for HBCUs and beyond*. Taylor & Francis.

Pattison, S., Svarovsky, G., Corrie, P., Benne, M., Nuñez, V., Dierking, L., & Verbeke, M. (2016). Conceptualizing early childhood STEM interest development as a distributed system: A preliminary framework. *National Association for Research in Science Teaching Annual Conference*, Baltimore, MD. http://www.informalscience.org/conceptualizing-early-childhood-stem-interest-developmentdistributed-system-preliminary-framework

Pattison, S., Svarovsky, G., Ramos-Montanez, S., Gotan, I., Weiss, S., Benne, M., Nuñez, V., Corrie, P., & Smith, C. (2020). Understanding early childhood engineering interest development as a family-level systems phenomenon: Findings from the Head Start in Engineering project. *Journal of Pre-college Engineering Education Research*, *10*(1), 6. https://doi.org/10.7771/2157-9288.1234

Paulsen, C. A., Cardella, M. E., Jones, T. R., & Wolsky, M. (2015). Informal pathways to engineering: Interim findings from a longitudinal study. *Proceedings of the 2015 ASEE Annual Conference & Exposition*, Seattle, WA. https://doi.org/10.18260/p.24299

Pew Research Center. (2018). *Women and men in STEM often at odds over workplace equity*. https://www.pewresearch.org/social-trends/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/

Polkinghorne, D. E. (1995). Narrative configuration in qualitative analysis. *International Journal of Qualitative Studies in Education*, *8*(1), 5–23. https://doi.org/10.1080/0951839950080103

Revelo, R. A. (2015). *Engineering familia*: *The role of a professional organization in the development of engineering identities of Latina/o undergraduates* [Unpublished doctoral dissertation]. The University of Illinois.

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

Russell, M. L., & Atwater, M. M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with African American students at a predominantly White institution. *Journal of Research in Science Teaching*, *42*(6), 691–715. https://doi.org/10.1002/tea.20068

Samuelson, C. C., & Litzler, E. (2016). Community cultural wealth: An assets-based approach to persistence of engineering students of color. *Journal of Engineering Education*, *105*(1), 93–117. https://doi.org/10.1002/jee.20110

Schwartz, L., & Gutierrez, K. (2015). Literacy studies and situated methods: Exploring the social organization of household activity and family media use. In, J. Rowsell & K. Pahl (Eds.), *The Routledge handbook of literacy studies*. Routledge.

Secules, S., McCall, C., Mejia, J. A., Beebe, C., Masters, A. S., Sánchez-Peña, M. L., & Svyantek, M. (2021). Positionality practices and dimensions of impact on equity research: A collaborative inquiry and call to the community. *Journal of Engineering Education*, *110*, 19–43. https://doi.org/10.1002/jee.20377

Smith, F., & Hausafus, C. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education*, *82*(1), 111–125. https://doi.org/10.1002/(SICI)1098-237X(199801)82:1<111::AID-SCE6>3.0.CO;2-K

Solórzano, D. G., & Yosso, T. J. (2002). Critical race methodology: Counter-storytelling as an analytical framework for education research. *Qualitative Inquiry*, *8*(1), 23–44. https://doi.org/10.1177/107780040200800103

Svarovsky, G., Cardella, M., Dorie, B., & King, Z. (2017). Productive forms of facilitation for young girls during engineering activities within informal learning settings. *American Educational Research Association Annual Meeting*.

Tan, E., Calabrese Barton, A., & Benavides, A. (2019). Engineering for sustainable communities: Epistemic tools in support of equitable and consequential middle school engineering. *Science Education*, *103*, 1011–1046. https://doi.org/10.1002/sce.21515

Tenenbaum, H. R., Snow, C. E., Roach, K., & Kurland, B. (2005). Talking and reading science: Longitudinal data on sex differences in mother-child conversations in low-income families. *Journal of Applied Developmental Psychology*, 26(1). https://doi.org/10.1016/j.appdev.2004.10.004

Tolbert, D. (2017). *Living*, *learning*, *and leveraging*: *An investigation of Black males accessing community cultural wealth and developing engineering attributes* [Unpublished doctoral dissertation]. Purdue University.

Tolbert, D., & Cardella, M. (2016). What they say: Black children talk about learning engineering. Paper presented at the IEEE Frontiers in Education Conference, Erie, PA. https://doi.org/10.1109/FIE.2016.7757648

Tõugu, P., Marcus, M., Haden, C. A., & Uttal, D. H. (2017). Connecting play experiences and engineering learning in a children's museum. *Journal of Applied Developmental Psychology*, *53*, 10–19. https://doi.org/10.1016/j.appdev.2017.09.001

Tucker-Raymond, E. (2020, September 21). *Questions I ask myself as a White researcher*. Informal Science. https://www.informalscience.org/news-views/questions-i-ask-myself-white-researcher

Tucker-Raymond, E., Gravel, B. E., Wagh, A., & Klimczak, S. (2018). Learning STEM in making: "All lives can't matter until Black lives matter". *Hands On!* Spring, 7–10. https://www.terc.edu/publications/stem-learning-while-making-all-lives-cant-matter-until-black-lives-matter/

Verdín, D., Smith, J. M., & Lucena, J. (2021). Funds of knowledge as pre-college experiences that promote minoritized students' interest, self-efficacy beliefs, and choice of majoring in engineering. *Journal of Pre-College Engineering Education Research (J-PEER)*, *11*(1), https://doi.org/10.7771/2157-9288.1281

Vossoughi, S., Hooper, P., & Escudé, M. (2016). Making through the lens of culture and power: Toward transformative visions for educational equity. *Harvard Educational Review*, *86*, 206–232. https://doi.org/10.17763/0017-8055.86.2.206

Vygotsky, L. (1978). Interaction between learning and development. *Readings on the Development of Children*, *23*(3), 34–41.

Walther, J., Sochacka, N. W., & Kellam, N. N. (2013). Quality in interpretive engineering education research: Reflections on an example study. *Journal of Engineering Education*, *102*(4), 626–659. https://doi.org/10.1002/jee.20029

Wickware, P. (1997). Along the leaky pipeline. *Nature*, *390*, 202–203. https://doi.org/https://doi.org/10.1038/36639

Wilson-Lopez, A., & Acosta-Feliz, J. (2021). Transnational Latinx youths' workplace funds of knowledge and implications for assets-based, equity-oriented engineering education. *Journal of Pre-College Engineering Education Research (J-PEER)*, *11*(1). https://doi.org/10.7771/2157-9288.1289

Wilson-Lopez, A., Sias, C., Smithee, A., & Hasbún, I. M. (2018). Forms of science capital mobilized in adolescents' engineering projects. *Journal of Research in Science Teaching*, *55*, 246–270. http://doi.org/10.1002/tea.21418

Wright, B. L. (2011). Valuing the everyday practices of African American students K-12 and their engagement in STEM learning: A position. *Journal of Negro Education*, *80*(1), 5–12. https://doi.org/10.2307/41341101

Wright, C. (2011). *Learning to "see" sound: An investigation into the intellectual and linguistic resources that urban middle school African American boys utilize in the practice of representing sound transmission* (Publication No. ATT3460849). ProQuest Dissertations Publishing.

Yosso, T. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education*, *8*(1), 69–91. https://doi.org/https://doi.org/10.1080/1361332052000341006

Yun, J., Cardella, M. E., & Purzer, S. (2010). Parents' roles in K-12 education: Perspectives from science and engineering education research. *American Educational Research Association Annual Meeting*, Denver, CO.

Appendix A. Initial Study Details

The original study was a qualitative, single-group, interrupted times series study that collected surveys and semi-structured interviews from 60 middle school youth and parents over their middle school careers. The goals of that study, based on social cognitive career theory, were to identify informal activities and pathways that influenced youth's decisions to pursue or discontinue pursuit of engineering as a college major and future career. Informal activities were activities, resources, or events that occurred outside of a school setting with which kids can engage alone or with others on their own time.

Participants were recruited via free publications and websites, personal networks, flyers in book and toy stores, and a research panel of families who permitted recruitment. Youth were eligible if they had internet access at home and could communicate in English. Participants were invited based on their responses to a 20-item eligibility screener that included baseline behavior and six motivation and seven participation factors. The baseline behavior questions related to building, creating, and playing with engineering-related toys or on websites. After participants were invited, consent and assent forms were provided to youth, parents, and any available related educators. Interviews (youth and parent) were audio-recorded and transcribed, and pseudonyms were assigned. Interview transcripts were analyzed to allow for themes and narratives to emerge, and rich narratives were then written for each family using thematic and narrative analysis. As the goal of the study was not to conduct a narrative inquiry, the participant stories were not shared with them for fact-checking or co-creation of stories.

Appendix B. Sample Interview Questions for Parents and Children in Years 1, 2, and 3

Year 1 Sample Interview Questions (Parent)

1. So what characteristics best describe her?
2. What are some of the other things that you think she's good at?
3. So what do you all do for fun with her?
4. What does she like to do for fun alone or with her friends?
5. Let's talk about any summer camps or afterschool programs that she participates in, focused on the music or the art or the technology.
6. What does she say she wants to be?
7. So you feel very encouraged and happy about all of the designing and creating and building that she does?
8. So do you think middle school should teach designing, creating, and building things?
9. So in the tech club yes, but what about in any of the other courses or offerings? Do you think she's learning any designing, creating, or building at school?
10. Since you work with engineering and you're in IT, how do you think engineering is different from science?
11. Very good. That was a wonderful answer. How do you think engineering is different than design?

Year 2 Sample Questions (Parent)

1. What characteristics best describe her today?
2. That's good. What are some of the things you would say she's currently good at?
3. Okay. What does she like to do for fun alone?
4. What does she like to do with her friends?
5. How much influence would you say her friends have over her decisions to join certain clubs or do certain activities?
6. Has she done any summer camps or clubs or other activities focused on the music, or she's still in 4-H or has she added any activities since we last talked?
7. What other additional things is she doing?
8. Well, we try to change the questions up just a little bit. How do you identify activities for her to participate in?
9. Do you ever have any challenges finding activities for her?
10. Are there any special things that you all do to help her learn about designing, creating, and building? I know you let her use the check to buy the materials or anything like that, and dad is helping her build. Is he doing the cutting or is she getting someone else to do the cutting?
11. Do you like to design or build things, or create things?
12. Do you talk about college with her?

13. So if she wanted… But if it looked like she was like, you think she could be a good engineer, and if she turns out what she wanted to study design or engineering or something for a living, how would you…
14. That's good. Are there any resources that you wish you had that you currently don't have?

Years 1–3 Sample Interview Questions (Child)

1. How would you describe yourself to somebody who doesn't know you?
2. How many brothers and sisters do you have?
3. Okay. So how would you describe yourself to somebody like me who doesn't know you?
4. What kinds of things are you interested in?
5. What kind of things do you think you're good at?
6. So I have this chart that I'm going to ask a couple of questions, I want you to help me fill it out. So let's think about since the beginning of the school year, since September, if you've done any of these activities. And I want to know if it was part of the school day or part of a school activity, or if it was outside of school like it was a club or after school or something.
7. So have you visited a science museum, a planetarium, or an environmental center?
8. And outside of school. Where did you go?
9. Have you watched a TV show, a webisode, or a DVD related to designing, creating, or building?
10. Have you used websites that contain games or stories related to designing, building, or creating—like Designs Coordination or Engineer Your Life?
11. Have you played a computer game like SimCity or Minecraft that was related to designing, creating, or building?
12. Have you read a book about designing, creating, or building?
13. In or out? In school or out of school?
14. Have you played with engineering-related toys like LEGOs, Kinects, or ROBLOX?
15. In or out?
16. Okay. Have you taken apart things, like motors or computers or toasters, to see how they work?
17. Have you participated in a competition to design, create, or build something?
18. And have you participated in the activity where you designed, created, or built something as part of a school club or after school or summer camp?
19. Oh, okay. So have you participated in a math club or a camp as part of a school club or after school?
20. Are you interested in designing, and building, and creating things?
21. What about problem-solving?
22. What kind of things do you like to design and create?
23. Do you do this work by yourself?
24. Do you think you're good at building things or making things?
25. All right. Is it because of the drawing part that you don't think you're good at it, or is it other stuff?
26. How do you think that helps you? Making things or inventing things.
27. Where have you learned about designing, creating, or building?
28. Cool. So if there was an adult who did the kind of work where they designed, created, and built stuff for a living, what would you call that?
29. So have you thought about what you want to be when you grow up?
30. Because last year you had some ideas. Have those ideas changed?
31. So, well, do you have any jobs that you know you don't want to go into?
32. So who talks to you about career choices?