Black Girls Create

Developing a Culturally Responsive Maker Program for Black Girls

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Afterschool programs are a significant vehicle for increasing STEM interest, confidence, and capacity in underrepresented students (National Research Council, 2009). According to the Coalition for Science After School (2007), effective afterschool programs provide relevant, hands-on opportunities for underrepresented youth to interact with relatable scientific role models, content knowledge, and resources.

This article describes the development and pilot implementation of a culturally responsive maker afterschool program for Black girls. The pilot of Black Girls Create used social history, culturally responsive pedagogy, and mentoring to engage Black girls in maker-based activities as they learned about Black "Her-STEM" figures: women who made significant impacts in STEM. By the end of the program, girls had used their new maker skills to design and create cultural artifacts and to conduct digital fabrication demonstrations. This article highlights the program design, pilot program outcomes, and successes and challenges associated with the pilot implementation.

The Status of Black Girls in STEM

The National Assessment of Educational Progress reports that African American students and girls in all grade levels consistently score lower than their white and male counterparts, especially in the sciences (National Center for Education Statistics, 2010). Local schools in urban neighborhoods in Boston, where Black Girls Create was implemented, mirror the national trend of underperformance in math and science

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(Massachusetts Department of Elementary and Secondary Education, 2020). For Black girls, low performance in science and math and on standardized tests of all kinds poses obstacles for high school graduation and entry into college, thus foreclosing their participation in STEM fields in adulthood (National Science Foundation, 2013; Perna et al., 2009).

Research shows that Black girls do not significantly differ from other students in their aptitude for learning science and math content (Campbell, 2012; Crenshaw et al., 2015; Grossman & Porche, 2013). However, they do differ in their interest and confidence in STEM subjects, and this difference negatively affects their performance. Poor performance in science and math has both direct and indirect implications for Black girls' future career options; it limits access to competitive colleges and universities, influences college major selection and college persistence, and precludes entry into the STEM workforce (Campbell, 2012).

Student identities such as race, gender, and class, as well as teacher responses to these identities, are shaped by broad social trends and realities beyond the classroom (Campbell, 2012). Society often perpetuates false beliefs about how race and gender negatively influence students' ability to learn math and science. Moreover, the belief that math and science ability is innate and related primarily to one's gender or race poses threats to Black girls' interest and confidence in these subjects (Davis, 2019). Negative stereotypes can raise doubts and anxieties in Black girls' minds, thereby limiting their confidence in their ability to learn science and math (Grossman & Porche, 2013). Using 893 cases from the 2002 National Education Longitudinal Study, Campbell (2012) examined Black girls' perceptions of math and how those perceptions affected teachers' recommendations for higher-level math courses. In this study, 91 percent of Black girls believed that people could learn to be good at math; however, 53 percent did not view themselves as capable math learners (Campbell, 2012). Low confidence in their own ability may explain why 51 percent of these Black girls indicated that they did not participate during math class.

Black girls exist at the intersection of two social identity groups that are underrepresented in STEM. That intersectionality is an essential lens through which girls process their experience in STEM education (Crenshaw et al., 2015). Black girls' inability to identify with STEM is due to myriad factors, including the absence of role models from their communities, consistently alienating experiences in science and math classes, unengaging class instruction, and the lack of connection between the content and their daily lives (Calabrese Barton & Tan, 2018; King & Pringle, 2018). By attending to the psychological meaning and experience associated with being a Black girl in out-of-school STEM education, afterschool practitioners can help Black girls perform better in math and science (Ireland et al., 2018).

Approaches to STEM learning that are culturally relevant and caring (Parsons, 2008) and that validate and use students' cultural resources (Calabrese Barton et al., 2017; Tan et al., 2013) have been shown to strengthen Black girls' engagement in STEM learning. Afterschool programs designed to create meaningful, engaging STEM learning opportunities for Black girls can bridge the gap between STEM learning and confidence in STEM. Programming that enables Black girls to see people like themselves working in STEM is another factor that afterschool programs can address (Archer et al., 2015; Davis, 2019; Kang et al., 2019).

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Project Rationale

Unlike many STEM programs (Calabrese Barton & Tan, 2018), Black Girls Create addresses issues of equity, inclusion, and relevance for Black girls by providing a curriculum and a learning environment that incorporates girls' cultural and intellectual histories and expands the meaning and purposes of STEM learning.

A unique aspect of Black Girls Create is that it focuses on making and maker culture. Maker afterschool programs in which girls learn about digital fabrication and engage in STEM in meaningful ways are associated with improvements in their STEM interest and self-efficacy (Techbridge Girls, 2020). Making can involve traditional craft and hobby techniques, such as sewing or woodworking. It often incorporates digital technologies in either manufacture or design. For example, manufacturing processes might use laser cutters or 3D printers; designs might use microcontrollers or LED lights for specific effects (Martin, 2015). Digital fabrication involves the design and manufacturing of products using advanced technology. Common forms of digital fabrication are computer numerical control (CNC) machinery, 3D printing, and laser engraving and cutting.

Maker spaces and related activities give young people who have disengaged from formal STEM instruction opportunities to design, tinker, and build in nontraditional ways, thus enhancing their confidence and interest in STEM (Calabrese Barton & Tan, 2018). Making gives youth access to sophisticated digital tools they can use to build, create, and think (Martin, 2015). Maker learning can engage underrepresented youth and broaden participation in STEM by centering on digital fabrication activities that make sense specifically to learners from a particular cultural background (Searle & Kafai, 2015).

Culturally responsive making is an emerging field in both research and practice in informal STEM learning environments (Searle et al., 2017). For this project, culturally responsive making is operationally defined as tapping cultural knowledge and maker technologies to engage young people in creating, designing, and producing artifacts related to a particular concept, theme, or person. It connects with learners' interests and activities along a spectrum of cultural practices, from traditional to vernacular. It also engages youth in cultural affirmation and sociocultural critique. Making situated in an appropriate cultural context can broaden participation by young people from underrepresented groups and address identity gaps that prevent these young people from seeing themselves as capable STEM learners and future STEM professionals. For example, Searle and Kafai (2015) examined how participating in culturally responsive making shaped Native American girls' sense of agency in STEM. The findings suggest that introducing girls to making and engineering concepts in ways that feel familiar can expand their ideas about what they can do.

Black Girls Create engaged Black girls in digital fabrication to increase their interest in STEM and their confidence in their ability to learn STEM. Its culturally responsive pedagogy focused on Black women's contributions in STEM. The combination of making, social history, cultural responsiveness, and mentoring addressed the participation gap and identity gap experienced by Black girls in ways designed to lead to more positive racial and gender identities.

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Incorporating culture into program design and implementation was a critical feature of Black Girls Create. Culture is the mechanism through which people learn how to be in the world, how to behave, what to value, and what gives meaning to their lives. Culture is the context for learning, whether in formal or informal settings. Acknowledging and incorporating participants' culture helps them create meaningful connections to academic subjects—particularly when they are members of underrepresented groups who may believe that certain subjects are unrelated to their current or future lives. For example, many Black girls and young women believe that science and math are not interesting and that the content is too difficult for them to master (Bowe et al., 2015; Campbell, 2012). As a result, many of them disengage from learning and fall behind in these core subjects. Decades of research show that situating learning within students' cultural context and connecting academic subjects to their cultural knowledge produce better academic outcomes. When these connections are made, especially in science and math, learners are more likely to show interest in the subject, engage in all aspects of the learning process, and master the content (Aronson & Laughter, 2016; Gay, 2000; Ladson-Billings, 1995).

Guiding Principles and Curriculum Development

Black Girls Create is a research project I conducted at Wellesley Centers for Women, Wellesley College. To design and implement the program, I developed the five research-based guiding principles outlined in Table 1.

Using these five principles, I designed the curriculum outlined in Table 2. A network of STEM professionals, makers, educators, and youth program specialists reviewed the program goals, principles, and curriculum to ensure that all aspects were aligned. After addressing these professionals' concerns, I pre-

Table 1. Black Girls Create Program Principles

Principle	Application in Program Development and Implementation
STEM capacity building	STEM capacity building is an approach to academic and career development that acknowledges psychological and performance factors that shape learners' interest in STEM content and their confidence in their ability to master that content. In this project, the psychological domain of capacity building focused on understanding participants' individual, relational, and collective selves and how those identities related to STEM learning. The performance domain focused on enabling participants to use science and math skills to create graphic designs and produce digitally fabricated cultural artifacts.
Culturally responsive informal learning	The project's safe, culturally responsive informal learning environment encouraged Black girls to develop interest and confidence in STEM by building on their cultural knowledge, prior experiences, and performance styles. Situating math and science learning in the context of participants' cultural history helps Black girls develop academic STEM knowledge and intellectual tools in ways that legitimize what they already know and have an interest in (Gay, 2000).
Her-STEM (historical female STEM models)	Conducting research about Black women who made significant contributions to STEM encourages Black girls to identify with STEM and make meaningful connections between STEM learning and historical figures. By learning about Black women in STEM, participants were expected to develop positive attitudes about their STEM learning capacity and to become invested in gaining the knowledge and skills necessary to design and create cultural artifacts.
Mentorship	Interacting with and learning from relatable STEM mentors is an integral aspect of Black Girls Create. Access to mentors can foster interest and confidence in STEM. In Black Girls Create, a mentor informed curriculum design, delivered content, and cultivated relationships with participants.
Self-reflection	Learning to identify and reflect on beliefs that either support or inhibit STEM interest and confidence equips girls to process and combat current and future STEM education barriers.

sented the program components to my advisory board for approval in fall 2018.

Program Implementation

Black Girls Create began as a pilot program in fall 2018. A pilot of a new educational program helps developers identify strengths and weaknesses so they can address any problems before full implementation. To implement the pilot, I established a partnership with Lena Park Community Development Corporation in Dorchester, Massachusetts. Lena Park is a multi-service center developed for and by community residents; programs range from early childcare and afterschool education to recreation and job training. Lena Park is part of the international network of approximately 1,000 Fab Labs, which nurture STEM education in collaboration with local nonprofits, K–12 schools, and higher education institutions. Before choosing Lena Park, I investigated three Fab Labs located in metropolitan Boston neighborhoods where many Black families live. Lena Park Fab Lab met the program's needs, in part because it is equipped with a full array of technical tools for digital and traditional fabrication.

I facilitated the pilot of Black Girls Create with two groups: Group 1 had seven participants and Group 2 had eight. Group 1 began in November 2018 and concluded in February 2019; Group 2 ran from April 2019 to June 2019. The age range of participants was 11 to 14, with an average of 12.2. I recruited participants from the local public charter school, an Afrocentric shopping bazaar, and social media. Using a video, flyers, and posters, I talked during grade-level morning assemblies at the school with students and teachers in grades 6 through 8. I also posted digital flyers on Wellesley Centers for Women's social media pages and shared them with my own social networks. This information was organically shared by at least 25 different people, thus widening the posts' reach; several pilot applicants were recruited this way.

Table 2. Black Girls Create Curriculum

Unit	Objective	Activities	Competencies
STEM capacity building	Participants develop the attitudes, knowledge, and skills needed to create artifacts using digital fabrication.	Participants begin to learn use of digital fabrication tools, including vinyl cutter, laser cutter, and 3D printer.	Computer-aided design Problem solving Math and spatial reasoning Vector design Ordering, sequencing, and visualizing Creativity
Research and design	Participants develop positive attitudes about their STEM learning capacity and invest in learning the knowledge and skills necessary to design and create artifacts.	Participants research their assigned historical figures and write their figures' histories, including career pathways and significant STEM contributions.	Awareness of STEM fields and careers Storytelling, creative thinking Data gathering, fact-checking, data analysis, reporting Oral communication
Making	Participants learn to use digital fabrication tools and develop their graphic design skills.	Participants use their graphic design and digital fabrication skills to create an artifact representing their selected historical figure.	Safety and operational procedures for use of digital tools Computer-aided design Problem solving Math and spatial reasoning Ordering, sequencing, and visualizing Creativity
Community demonstration	Participants demonstrate what they have learned. The long-term success of efforts to address participants' attitudes about STEM depends on their families, who may also benefit from activities that challenge their beliefs about STEM.	Participants demonstrate their knowledge of maker skills and of their assigned Black female STEM pioneer during the closing meeting. Participants demonstrate how to use digital fabrication tools.	Critical thinking, analytical skills Self-reflection Metacognition

Potential participants completed an online application, which collected demographic information and verified participants' availability for all program sessions and caregivers' availability for the parent orientation. I received 15 applications for Group 1 but could accept only nine applicants because the site had only nine desktop computers and because funding permitted the hiring of only one group mentor. From the 15 applications, I selected seven participants for Group 1 who indicated that they were available to attend all program meetings and that their caregivers would attend the orientation. Participants in Group 2 emerged from a partnership between Lena Park Fab Lab and Harlem Lacrosse, an afterschool sports program. I implemented a modified version of the 12-week program with Group 2.

All Black Girls Create activities were held at Lena Park Fab Lab. I collaborated with an undergraduate African American female mentor to conduct weekly two-hour work sessions with each of the two groups. Group 1 participated in 12 weeks of programming, and Group 2 had seven weeks. Work sessions centered on specific learning outcomes associated with the general outcomes of the program.

Each session began with a recitation of the Black Girls Create pledge, which was created by program participants during the first session. The pledge helped to foster participant ownership of the program. Then participants shared information about their Her-STEM figures and brainstormed ideas for their final projects: digitally fabricated cultural artifacts representing those historical figures. Next, I taught the day's STEM capacity-building skills, which then were demonstrated by me or the undergraduate mentor. For example, on the day when the group made Black Girls Create T-shirts, participants needed to learn about two-dimensional design and about safe operation of the vinyl cutter and heat press. After watching the demonstration, participants practiced what they had learned to produce a product, in this case, a T-shirt. Every work session included work with digital fabrication equipment. At the end of each session, participants recorded in their journals what they had learned and enjoyed that day. Each work session was designed to build the confidence, knowledge, and skills participants would need to create their final projects.

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The primary program outcome for this pilot study was the completion of the final project. Participants selected a Black Her-STEM figure, conducted research about that figure, designed (with support) an artifact to represent that figure, produced the artifact using one or more of the digital fabrication tools in the Fab Lab, and presented the artifact to their families during the last program session. Leading up to the final project, program activities helped participants develop the skills necessary to plan, design, and create their artifacts. For example, in addition to using the vinyl cutter and heat press to create customized T-shirts, participants also used the vinyl cutter to design and create stickers for their journals and used Inkscape graphic design software and a laser cutter to create a two-dimensional image of a Black girl.

Of the 15 participants in the two groups, 10 completed the final project: four of the eight in Group 1 and six of the seven in Group 2. The program schedule was a significant factor in Group 1's completion rate. The weekly work sessions began in November and ended in February; in the middle was a two-week winter break in which no sessions were held. Some participants stopped attending after the break.

Although participants learned how to create both two- and three-dimensional designs and to use a vinyl cutter, 3D printer, and laser machine, most used the laser machine to create their final projects. Only one used the 3D printer; she created three-dimensional animal figures to represent the first black female zoologist, Dr. Roger Arliner Young. Other participants created key chains, wall art, earrings, pendants, and other items to represent Her-STEM figures and their contribution to STEM. For example, the participant who conducted her research on Dr. Shirley Jackson, the physicist who invented caller ID and call waiting, designed and digitally fabricated a wooden iPhone with Dr. Jackson's name and a phone number on the screen. All participants who completed the program demonstrated their creativity, their knowledge of digital fabrication, and the results of their Her-STEM research.

Lessons Learned

In addition to program outcomes, the pilot implementation of Black Girls Create yields valuable information about the successes and challenges of designing and implementing afterschool programs for Black girls and other marginalized youth. Two factors that were key for this innovative afterschool STEM program were effective partnerships and intentional recruitment strategies.

When I visited the three Boston-area Fab Labs located in largely Black neighborhoods, I considered many factors, including the availability of equipment, the lab's accessibility to the surrounding community, and the extent to which the leaders expressed interest in serving Black girls. A critical factor was how welcoming the organization's leaders were to me, a Black female researcher and educator, and to other outsiders. Meanwhile, I already had established relationships with the Fab Foundation (the parent organization of local Fab Labs), Lena Park, and the charter school from which I recruited participants. My ongoing involvement as a maker in local cultural events had earned credibility that helped me gain access to key stakeholders and institutions in the community. My presence in the community before, during, and after the pilot project helped create the organizational and community buy-in needed to run a successful afterschool program.

Another key to success was intentional recruitment. Before reaching out, I created culturally representative recruitment materials, including a video in which I shared information about Black Girls Create as well as posters and flyers using culturally representative photos. The middle school I visited to recruit girls is more than 50 percent Black. Social media was another important recruitment tool, as was my own established visibility in the community.

The two main challenges of the pilot implementation were lack of available mentors and participant attrition. The college students who expressed interest in serving as program mentors faced the challenge of traveling the 30 miles from the college campus to the project site, a three-hour round trip by bus. The mentor who did commit to the program despite the long commute grew up near the project site and was eager to serve her community through this project.

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Problems with attendance affected participants' ability to fulfill the program requirements. Several participants dropped out due to competing responsibilities and involvement in other extracurricular activities. Group 1 had more attendance issues than Group 2, likely because of the difference in program length: 12 sessions over four months for Group 1 and seven sessions over two months for Group 2. Some Group 1 participants dropped out after the winter break, which was not a factor for Group 2.

Implications and Future Directions

Maker-based learning environments provide spaces for youth who are disengaged from STEM to engage in designing, tinkering, and building in ways that foster their confidence and interest in STEM learning (Calabrese Barton & Tan, 2018). These spaces engage students in STEM-based activities that make sense in their world and help them develop maker identities consistent with their cultural identities. Black Girls Create exposed participants to STEM in a nontraditional way and gave them access to digital tools that would otherwise be out of their reach. Culturally responsive making has the potential not only to broaden participation of Black girls in STEM but also to address identity gaps that can prevent girls from seeing themselves as capable STEM learners and future STEM leaders (Searle et al., 2017; Searle & Kafai, 2015).

My research contributes to the body of knowledge in informal STEM education by examining how a culturally responsive maker program was designed to influence Black girls' interest in STEM and their multiple identities. This project built on culturally responsive educational theory and research, which consistently show how culture, interest, and identity affect student learning. Black Girls Create and similar programs leverage experiences with gender-specific and culturally embedded curricula to strengthen Black girls' interest and confidence in STEM and their related racial and gender identities (Scott & White, 2013; Scott et al., 2015). This and similar innovative, collaborative approaches have the potential to broaden participation among a population that is grossly underrepresented in STEM fields.

I plan to conduct further research to develop a conceptual model for engaging underrepresented groups in informal STEM learning spaces in the context of making, sociocultural history, and identity development. Further research on the impact of culturally responsive maker programs on Black girls' STEM interest, STEM confidence, and multiple identities can help K–12 teachers, informal STEM educators, educational researchers, and institutions of higher education to develop strategies to broaden STEM participation and thereby contribute to a diverse, globally competitive STEM workforce.

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