Cultural Studies of Science Education (2022) 17:39–52
https://doi.org/10.1007/s11422-022-10105-8

ORIGINAL PAPER

Making "it" matter: developing African-American girls and young women's mathematics and science identities through informal STEM learning

Crystal Morton[1] · **Demetrice Smith-Mutegi**[2]

Received: 4 September 2021 / Accepted: 24 January 2022 / Published online: 22 March 2022

Abstract
This article describes a summer enrichment science, technology, engineering, and mathematics (STEM) camp for African-American girls and young women aimed at addressing mathematical and science self-efficacy and reinforcing the importance and usefulness of mathematics and science with a socially transformative curriculum. The research questions guiding this study are (1) How do African-American girl participants describe their experiences in Girls STEM Institute (GSI)? and (2) How does the STEM program experience affect their mathematics and science self-efficacy and valuing of mathematics and science? The data, which included journal entries and interviews, were collected and analyzed from four participants and indicated that participating in the Girls STEM Institute led to improved mathematics and science self-efficacy and increased perceptions of the value of science and math knowledge.

Keywords Informal learning · African-American girls · Identity · STEM

> The worst thing that happened to me was when I was in the sixth grade, and I was in an advanced honors science class. And I would like to answer every question right, but when it came to finals or tests, I always did terribly. So finally, the teacher talked to me one day, and the only thing I remember her saying was, "You do know no college is going to accept you," and that was her exact words. And so, to me, that like, broke my spirit. I'm like, wow. And I have a passion for science. And I did share that

This manuscript is part of the special issue "Science education and the African Diaspora in the United States", guest edited by Mary M. Atwater and Jomo W. Mutegi.

✉ Crystal Morton
cranhill@iupui.edu

Demetrice Smith-Mutegi
dsmithmu@odu.edu

[1] School of Education, Indiana University-Purdue University Indianapolis, Indianapolis, IN, USA

[2] Darden College of Education and Professional Studies, Old Dominion University, Norfolk, VA, USA

> with my grandma and aunts and mom and they pretty much, you know, they helped me not to believe what she said. ~Anissa

Anissa's story is representative of the experiences of many African-American girls in traditional science and mathematics classrooms across the USA. African-American girls' experiences in mathematics and science classrooms occur at the intersections of their multiple identities (Evan-Winters 2011). They experience marginalization because of their gender and race (Neal-Jackson 2018).

Despite their higher value of mathematics and greater confidence in their abilities to do well in mathematics, African-American girls are held to lower expectations by teachers compared to their White counterparts (Else-Quest, Mineo and Higgins 2013). Often, teachers' low expectations result from the racial and gender stereotypes they hold about African-American girls, which negatively impacts the quality of instruction they receive (Joseph, Viesca and Bianco 2016).

African-American girls often describe their days in mathematics classes as follows: check homework, listen to a lecture, go over homework, receive instructions to read sections in the textbook, and get new homework. (Author 1 and Author 2 2018). African-American girls are less likely than other girls to receive multimodal learning experiences that foster critical thinking, productive discourse, and a sense of agency. In many cases, African-American girls find themselves in educational environments that do not foster their development as scientists and mathematicians.

Identifying ways to redress disparities in the educational experience of African-American girls is of vital importance for many reasons. First, African-American girls and particularly African-American girls from low-income neighborhoods are underrepresented in mathematics and science-related careers (National Science Foundation [NSF] 2003, as stated in West-Olatunji, Shure, Pringle, Adams, Lewis and Cholewa 2010). In its 2017 report Women, Minorities, and Persons with Disabilities in Science and Engineering, the National Science Foundation reported a decline in African-American women's share of bachelor's degrees in computer sciences, mathematics and statistics, and engineering (NSF 2017). In the undergraduate STEM field, African-American women held 5.1% of the degrees. In the mathematics and statistics field, only 2.3% of degrees went to African-American women. African-American women received about 5% of STEM master's degrees and less than 1% of mathematics and statistics master's degrees. African-American women received about 3.5% of all STEM doctorates and less than 1% of mathematics and statistics doctorates (NSF 2017).

Furthermore, we (co-authors) observed that African-American girls were more likely than other racial/ethnic groups to dismiss their mathematics and science abilities. The dismissing of their mathematics and science abilities was often connected to the negative messaging they received from their teachers about their intelligence as mathematics and science learners. When seeking resources on motivating African-American girls in mathematics and science and the causes of the disparities, we found a dearth of research. Finally, with the growing interest in STEM at both a national and international level, as well as persistent racial disparities in educational achievement, African-American girls must engage in cognitively challenging and relevant learning experiences that will support their success in mathematics and science and help them believe in their abilities as learners. The concept of self-efficacy is central when speaking about African-American girls and their beliefs about their abilities as mathematics and science learners. Self-efficacy refers to one's confidence that one can achieve a goal and is a significant predictor of learners' academic achievements (Bandura 1986).

Therefore, the purpose of this study is to describe how African-American girls' participation in Girls STEM Institute (GSI), an informal holistic learning program, shaped their mathematics and science identities. In this study, we examined mathematics and science identity as constructs of self-efficacy and the value attached to mathematics and science. We used a phenomenological approach to answer two guiding research questions: (1) How do African-American girls describe their experiences in GSI? and (2) How do their experiences in GSI affect their mathematics and science self-efficacy and valuing of mathematics and science?

Literature review

Recent literature on African-American girls' mathematics and science learning, self-efficacy in mathematics and science, and valuing of mathematics and science provide a framework for understanding the role of the GSI summer enrichment program in the development of African-American girls and their mathematics and science identities. These concepts will each be examined in more depth in the following sections.

Science and mathematics learning

The development of African-American girls' science and math skills is complicated by racial, socioeconomic, and gender issues (Joseph, Viesca and Bianco 2016). They are often stereotyped as loud, talkative, aggressive, confrontational, and assertive (Evan-Winters and Esposto 2010). These stereotypes lead to differential treatment by educators (Walker 2007) and are viewed as inconsistent with White femininity (National Women's Law Center and Girls for Gender Equity 2015). In response to these preconceived ideas about African-American girls, teachers devote more time to social corrective activities than helping them achieve academic success (Morris 2007).

African-American girls are often steered away from rigorous mathematics and science courses (Walker 2007). They are also often tracked into lower-level classrooms where access to critical thinking, engagement, and relevance is limited or nonexistent (Tate and Rousseau 2002), and they are often excluded from learning experiences that make vital connections between the content and their values, priorities, abilities, culture, and lived experiences (Mutegi 2011). Additionally, who they are as African-American girls is not valued, and their intellects are often viewed through a deficit lens (Martin 2012).

In these dehumanizing mathematics and science learning spaces, African-American girls have limited opportunities to learn relevant, cognitively challenging, and transformative science and mathematics content. Therefore, they often develop feelings of disconnectedness and a lack of belongingness (Malloy 1997). In order to learn, students need a sense of belonging and connections to the content. In the absence of these components, students will be less motivated to engage with mathematics and science, which in turn may affect their value of the content and their self-efficacy (Malloy 1997). Having access to STEM curriculum and experiences that challenge students to think deeply and critically and validate their everyday knowledge can result in students having the tools and desire to pursue a deeper understanding of STEM concepts (Malloy 2008) and increase their motivation to pursue STEM degrees and careers (Afterschool Alliance 2011).

Socially transformative curriculum

We believe that the design of educational programs, both formal and informal, plays an important role in the success of African-American students in math and science. Implementing a curriculum approach that values and affirms the experiences of students of color in relation to learning is essential (Mutegi 2011). Critical theorists, such as Paulo Freire, have long argued against educational systems that fail to prepare people to solve their problems (Foley, Morris, Gounari and Agostinone-Wilson 2015). Additionally, Jomo Mutegi (2011) argues that science should be taught through a socially transformative curriculum that positions African-American students to critically evaluate modern Western science while acquiring five types of mastery: content, currency, context, critique, and conduct.

As Mutegi (2011) points out, *content* relates directly to the course being taught. The relevance of a subject to human beings can be gauged from its *currency. Context* speaks to the relevance of the subject to African-American people. *Critique* speaks to the importance of helping students use their knowledge of the subject to better understand systemic racism. Last but not least, *conduct* highlights the importance of students engaging in civic activism on behalf of their community. Unfortunately, engaging students in learning how to solve their own problems is not a consideration of national standards or traditional classroom settings.

Informal learning settings

There has been an increase in informal STEM educational literature examining the ways in which students' experiences in informal environments complement their learning in formal settings. Erica Walker (2012) highlights the importance of considering the cultivation of identity development "within schools, outside of schools and the space in-between" (p. 66). Researchers have found that informal STEM learning (i.e., in museums, summer camps, and homes) has a positive impact on learners' interest and persistence in STEM subjects and STEM careers (VanMeter-Adams, Frankenfeld, Bases, Espina and Liotta 2014), especially programs rooted in students' social and cultural contexts (Martin 2012). In a study of STEM-related afterschool programs at a local charter school, researchers found that informal learning activities that encourage collaboration, community building, and ownership can cultivate STEM literacy among students (Sahin and Adiguzel 2014). Several studies have highlighted the importance of informal settings for STEM learning, but few have focused specifically on African-American girls and young women (McPherson 2014).

Ezella McPherson (2014) found that African-American women majoring in science, math, and engineering acquired cultural capital through informal learning environments like summer camps and museums (McPherson 2014). When looking at girls of color, Barbara Kerr and Sharon Robinson (2004) found that participation in informal STEM activities increased their exploration of STEM careers, achievement, and self-efficacy. It is suggested that informal learning experiences may contribute to the retention of African-American women in STEM disciplines by giving them a sense of inclusion in the culture of science (McPherson 2014).

Self-efficacy

Self-efficacy is an important area of study for educators who desire to increase student engagement and achievement within science and math (Brinter and Pajares 2006). Self-efficacy is often defined as the confidence one has in one's ability to complete a task or reach a goal and involves judging one's ability (Bandura 1986). The literature discusses four primary sources of self-efficacy. These include personal experiences, vicarious experiences, social persuasions, and physiological situations. Math and science achievement are often predicted by personal experiences since students' self-efficacy in math and science is higher when they have successful mathematics and science learning experiences (Britner and Pajares 2006).

Within general academics and specifically mathematics and science, students' self-efficacy can significantly affect their effort, perseverance when facing difficulties, learning, course enrollment, career choices, academic performance, and overall success (Yurt 2014). According to Jemimah Young, Kelly Feille, and Jamaal Young (2017), when African-American girls' self-efficacy is developed, they feel more confident as members of the scientific community and are more likely to position themselves favorably in the classroom.

Valuing

"Values are core conceptions…that serve as standards or criteria to guide not only action but also judgment, choice, attitude, evaluation, argument, exhortation, rationalization, and one might add, attribution of causality" (as cited by Luttrell, Callen, Allen, Wood, Deeds and Richards 2010, p. 143). Oftentimes, task value and self-efficacy correlate positively, and both are proven as predictors of various academic outcomes (Meece, Wigfield and Eccles 1990). Students are usually motivated to learn and persist in areas where they find value and meaning (Brophy 1999).

Jacquelynne Eccles, Terry Adler, Robert Futterman, Susan Goff, Caroline Kaczala, and Judith Meece (1983) proposed that expectancy and task value beliefs impact students' academic performance, choices, and level of perseverance. The value a person attaches to engaging in a task is contingent upon the ability of the tasks to "fulfill needs, facilitate reaching goals, affirm personal values, and elicit positive versus negative affective associations" (Eccles, Adler, Futterman, Goff, Kaczala and Meece 1983, p. 89). Eccles, Adler, Futterman, Goff, Kaczala, and Meece (1983) define task values as the perceived importance of a task, based on

a. The usefulness or relevance of other tasks or aspects of life (utility value),
b. The enjoyability of engaging in the activity (intrinsic value),
c. The ability to do well on the activity (attainment value), and
d. The perceived negative aspects of engaging in the activity (cost value) (as cited in Hulleman 2010, p. 2).

Vickie Luttrell, Bruce Callen, Charles Allen, Mark Wood, Donald Deeds, and David Richards (2010) found that the most robust relationship existed between utility value and student interest. Students must value what they are learning in order to succeed. Students who value their learning experiences and find them relevant and useful to their lived experiences display increased engagement and academic achievement (Ryan and Powelson 1991). Valuing of one's learning experiences is also related to increased motivation (Eccles

and Wigfield 2002). Whether or not a student develops a sense of valuing for science and mathematics during the elementary and middle school years can have a profound impact on their math and science participation, grades, course enrollments, college enrollments, and career selection (Simpkins, Davis-Kean and Eccles 2006). Bradford Lewis and Shelley Connell (2005) found a connection between African-American students' science course-taking and their utility value. The majority of the students in their study reported career preparation, college preparation, and desire to learn more as reasons for enrolling in more advanced science courses.

Science and mathematics identity

Identity can be defined as how people conceptualize themselves and others and their resulting actions based on those conceptualizations (Aguirre, Mayfield-Ingram and Martin 2013). "Identities announce to the world who we think we are, who we want to become, or who we are not" (Aguirre, Mayfield-Ingram and Martin 2013, p. 14). One's identities are important because they serve as sources of strength and motivation to excel in school in general and mathematics and science specifically (Martin 2000). Danny Martin (2000) defines mathematics identity as one's belief about "(a) their ability to perform in mathematical contexts, (b) the instrumental importance of mathematical knowledge, (c) constraints and opportunities in a mathematical context, and (d) the resulting motivations and strategies used to obtain mathematics knowledge" (p. 19). In this study, we focused on African-American girls' beliefs about their ability to perform in mathematics and science contexts and their belief about the value of mathematics and science knowledge.

Phenomenology

According to Max Van Manen (1990), phenomenology aims to gain a deeper understanding of a person's lived experience and the impact of their lived experiences. Phenomenology focuses on using participants' words and perceptions to understand and interpret their experiences (Tesch 1987). In this study, phenomenology was selected as an analytical perspective because it allowed the researchers to gain a deeper understanding of African-American girls' (1) perceptions of their engagement in GSI and (2) how that engagement affected their self-efficacy and valuing of science and mathematics.

Methodology

Context

All participants in this study were enrolled in the GSI summer enrichment program. GSI is an informal STEM learning program designed to provide holistic learning opportunities for girls of color, who are historically marginalized in STEM fields. GSI utilizes a socially transformative STEM curriculum model that provides participants with opportunities to draw connections between the content and their lived experiences. The goals of GSI are to improve the achievement, perceptions, confidence, and overall wellness and well-being of girls of color and their families. Within GSI's rich, relevant, and supportive context, girls

Table 1 Participant descriptions

Name	Age	Grade	Type of school
Veronica	15	10	Traditional public
Jania	13	8	Traditional public
Sophia	14	9	Traditional public
Tiffany	17	11	Homeschool

are provided access to powerful STEM learning experiences that challenge them to think deeply and critically while allowing them the freedom to grow interpersonally and intellectually. GSI's vision is to transform communities by empowering girls of color to become leaders, innovators, and educators who use STEM as a tool for personal and social change (Author 1 and Author 2 2018).

Interested participants apply to enroll in the program, and applications are accepted until all program slots are full. During the program, participants engage in mathematics and science explorations, mathematics literacy instruction, community service projects; college campus visits; and social, leadership, and college preparatory development. Participants work with STEM professionals who share their same gender and race/ethnicity to help them see that STEM-related careers are within their reach (Britner and Pajares 2006).

Participants

During the summer of 2014, 19 girls in grades 4–11 enrolled in the program. Participants were purposefully selected for this study based on age and availability for follow-up interviews. We targeted middle and high school students for interviews. Four participants agreed to participate in the current study; each participant was asked to complete one follow-up interview after the GSI program ended. Table 1 provides a summary description of each participant. The study participants are a representative sample of the students enrolled in the summer 2014 program. Pseudonyms are used for all participants.

Veronica identifies herself as "on the verge of being an average student." She desires to graduate from high school and attend a school such as Juilliard to get her degree in music. Jania describes herself as a student whose favorite subject is math. She enjoys challenges and is not afraid to ask questions. Jania aspires to work in the medical field, possibly as an art therapist for kids. Sophia desires to become a pediatric neurosurgeon and describes herself as outgoing and confident. For Sophia, science has always been her favorite subject. Tiffany views herself as a good student. Tiffany hopes to become a cosmetologist.

Data collection

During the GSI program, participants completed journal entries. The journal entries related to the participants' day-to-day experiences during the program and their beliefs about mathematics and science. Some example journal prompts were.

1. What did you enjoy most about camp yesterday and why?
2. Before you started Girls STEM Institute, how did you feel when you heard the word "science"? Annoyed? Frustrated? Excited or bored?
3. How would you rate your ability to do mathematics and science?

After each young lady agreed to participate in the current study, they were contacted to schedule a time for a follow-up interview. Interviews ranged from 30 to 45 min and were audio-taped and transcribed. In the interviews, participants were asked to describe their school experiences, camp experiences, views of the value of mathematics and science, and level of self-efficacy. Sample interview questions included.

1. Do you feel like you understand the material you cover in your math/science class?
2. Would you say your grades accurately reflect your abilities in math/science?
3. After participating in Girls STEM Institute's summer enrichment program, would you say your belief in your ability to do math/science has increased, decreased, or remains unchanged? On a scale of 1–10, how would you rate your confidence in math/science?

Data analysis

This study utilized qualitative research methodologies to analyze student interviews and journal entries. The purposes of the student interviews and journal entries were to explore students' experiences during the GSI program, the levels of efficacy exhibited by students, and what value students found in mathematics and science. Interviews and journals were coded using open coding. After receiving the interview transcripts, we (co-authors) independently identified codes, then themes. Transcripts were reread and coded for selected themes. The themes emanating from the data included perceptions of GSI's climate and peers, beliefs about the importance of mathematics and science knowledge, and perceptions of self as a learner of mathematics and science.

Findings

The purpose of this study was to examine how African-American girls' experiences in GSI impacted their mathematics and science identities, as determined by their self-efficacy and value of mathematics and science. By examining the data, we identify relevant themes associated with their perceptions and beliefs. Those themes are described in the following section.

How do African-American girls describe their experiences in Girls STEM Institute?

Perceptions of Girls STEM Institute climate and peers. Their interviews and journals contributed to our understanding of the enrichment program environment. Participants described the informal learning program environment as a "comfort zone," one in which they felt safe to be themselves and to take academic risks. Building confidence among participants was catalyzed by the program environment. According to Veronica, "last week I felt okay being myself around them [the girls at the camp] without them making fun of me."

As the enrichment program continued, the environment was further enhanced by the ease of making friends. Tiffany stated:

> I had so much fun at the girls camp last week! When I first started, I didn't really click with anybody, and I thought I was just going to be a loner. On the second day, I met Sophia, and we instantly became friends. The summer camp has allowed me to make friends. I was able to connect with girls with bright futures

Tiffany also mentions the quality of her peers in this quote, emphasizing the positive connections she made at the camp.

For some, including Veronica, this sense of safety and comfort translated into a stronger belief in their ability to express ideas and opinions and also increased their confidence to reach out to others when they needed help.

> Like when I guess just being like around some of the girls and then knowing that they don't care if you are wrong or right. They don't care. They share their opinions too. Being around that environment for a while kind of makes you feel like oh since they are doing it you can do it too. You don't have to like keep all that inside. You can share your opinion about this too. ~Veronica
>
> I think it helped me to better prepare for working with other students in math so like, we all struggled with different things so if I was struggling in a certain part I had to reach out. The teacher isn't always available. ~Veronica

The increased confidence to reach out to others for help outside of the classroom teacher impacted participants' experiences in their traditional year-round classrooms as well. Jania realized that she must advocate for herself in the classroom and should not be afraid to seek help from or offer it to her peers.

> You have to reach out to other students that could help me instead of just waiting for the teacher. Some students understand better. If someone else needs help and they want to ask me, I have to be able to be confident enough to help them and know that I have the right answer. I think that helped me better prepare to work with everybody else if they needed help or if we just work together on a math problem. ~Jania

How did the Girls STEM Institute experience affect the participants' self-efficacy and valuing of mathematics and science?

Beliefs about the importance of mathematics and science.

Mathematics, as perceived by camp participants, primarily offered value in the area of utility. As participants identified, specific math skills are needed to work as a cashier, to buy items as consumers, to sell items, and to pay household bills. Science and mathematical concepts that were taught in the abstract held no relevance for participants. Tiffany and Veronica expressed similar sentiments:

> It would be like for a teenager to work somewhere like at McDonald's or Burger King. If I were a cashier, then I would have to use that math. I don't think I would have to use geometry anywhere. ~Veronica
>
> When I'm buying products, I have to think about how much product to buy. If I ever do sell my own products, like how to make a profit. You know how to like when I have a home when I'm living by myself in an apartment or something, how to calculate all my bills. I feel like when I do get out in the real world that I will be well prepared. ~Tiffany

After the camp, participants' views of the usefulness of mathematics had expanded and increased their belief in their mathematics ability.

> I used to think that I wasn't good at algebra and then after we did that shopping thing it showed me that I know how to use math in life and you have to budget and save and all that. Look for key things when you are shopping. ~Veronica
>
> I really liked that activity that we did when we had a certain amount of money like we had a certain career and we had to buy a house and get a car and stuff. I really

> liked that. We got to see if you had this type of career, how would you have to live your life. With the financial literacy part and the shopping part, I think that helped me think a little more about my future and how I want to use mainly my math skills in a positive way to think through all of my life choices that I'll have to deal with. ~Jania

Veronica and Jania found value in the shopping trip and financial simulation activities. They both saw how these activities connected to real life and how their success with these activities demonstrated that they could do the relevant math.

When asked to recall a memorable lesson from the camp, Veronica recalled a science lesson:

> The one thing that I remember is when we took the peppers. We took all the seeds out of the peppers, and we counted the seeds and oh and then we talked about the packaged pepper, and you can just grow your own

Veronica remembered that during a seed dissection lesson, she realized that the seeds in a pepper are the same seeds sold in packages at stores. As a result, she recognized the value of the science lesson through her understanding of the origination of seeds and that she could grow peppers on her own.

Perceptions of self as learner of mathematics and science. Participants spoke more in-depth about the camp's impact on their belief in their mathematics and science abilities, their confidence as learners, and their confidence in general. Participants were asked about their level of confidence in mathematics and science before the camp, and two said they lacked confidence in one or both areas, while the other two felt confident in both.

> I'm not really confident [when asked about math]. I just struggle. When I struggle, I don't feel as confident. ~Sophia
> I feel really confident in both. Just more in math. Just because that is what I'm more interested in. I am pretty confident about math because I've always enjoyed doing math equations, but I am not very confident in problem-solving. I love math, and if I study chemistry in college, that will deal with math. I think math is fun. ~Jania

In the program, the participants reported a change in their confidence and belief in their abilities to do math and science. Sophia and Veronica speak of this change in the quotes below:

> Actually, the algebra was positive. It helped with algebra. I mean, I feel like I wasn't that bad at algebra, but it was refreshing. I feel like I don't know how I feel. I feel good. I guess it kind of did build my confidence with algebra. ~Sophia
> I would have to say it increased. I say that because before, I wasn't really confident in math or science, and now after the camp, when I started school, I was kind of confident about it. I knew kind of what to expect, not in geometry but in science. It increased a lot in science. It increased in geometry as well but a lot in science after the camp. ~Veronica

Despite the participants' confidence in math and science, it was still possible for them to recognize how the camp would make a difference to the participants who lacked their confidence levels before the camp.

> The other girls, who kind of struggled in math or science or things like that, I think it builds up their confidence more and feeling comfortable in those areas. You can be uncomfortable just because you don't learn it, or you don't know it, and you don't

> understand it as much. You don't want to push yourself. I think if we had more experience in those subjects with other young girls then we could kind of feel more comfortable in school. ~Jania
>
> Just maybe say if they [other girls] were having a hard time making friends or having a hard time coming out of their comfort zone or staying in their shell, I would encourage them to do the camp. It is a great way to be exposed to new things. You meet a lot of new people. I know you have a lot of fun at the same time. You learn a lot. When the camp is over you will be sad that you don't get to see the friends that you made. You won't see the teachers or counselors. ~Tiffany

Discussion and implications

In this study, we explored how participation in a Girls STEM Institute program influenced African-American girls' mathematics and science identities as expressed by mathematics and science self-efficacy and their value of mathematics and science. The research questions guiding this study were (1) How do African-American girls describe their experiences in Girls STEM Institute? and (2) How do their experiences in Girls STEM Institute affect their mathematics and science self-efficacy and valuing of mathematics and science?

Both self-efficacy and valuing mathematics and science knowledge are positively related to academic achievement (Meece, Wigfield and Eccles 1990). It has been shown that the experiences African-American girls have in traditional mathematics classrooms negatively affect their beliefs in their mathematical and scientific abilities, and their attitude toward mathematics and science. The results of this study indicate that participants' mathematics and science learning experiences influence their self-efficacy and value of learning mathematics and science. The participants who expressed the lowest rankings for belief in their mathematics and science abilities before participation in GSI had previously experienced traditional classrooms that were not conducive to meaningful and deep learning. Participation in GSI provided girls and young women with the opportunity to develop math and science skills that were useful and meaningful to their interests and daily lives. Our findings suggest that these learning experiences impact their perceptions of mathematical and scientific knowledge as well as their self-efficacy.

In informal educational settings such as GSI, African-American girls may be able to counter some of the detrimental effects they might experience in more traditional educational settings. Our findings are consistent with Natalie King and Rose Pringle's work with Black girls in informal spaces (2019). Participation in GSI not only positively impacted African-American girls' mathematics and science identities but also affected their overall confidence.

> Before the camp, I used to be not that confident about my voice and then when we had the talent show at the end of the camp, I was in front of a lot of people. It kind of made me feel like if they like my singing, then I guess they think that I'm good. I never really wanted to be overconfident about that. I used to be not very confident about the way that I dress or the way that I look. I used to think I wasn't that beautiful. The camp kind of showed me that you are beautiful in your own way. ~Veronica

Veronica and Sophia's responses echoed the sentiments of participants who were asked if Girls STEM Institute should be year-round. They shared:

> This program has given me opportunities to meet new people that are actually nice. I like everything about it. From the conversations to the workshops to the time you sign out. This camp has enlightened me to how important education is. It has also given me another opportunity to show me that I could start my business and also how to manage my money. And it's only been a week. Think about when the program is done and how far we would have come and how much more I would learn. I love the program. ~Sophia
>
> There are girls out there that were like me before I started the camp. I think that this program or camp would benefit them because it benefited me a lot. It would show them what it showed me. You can be confident, and you are beautiful the way that you are. You don't have to change. Speak your mind and opinion about subjects and all that. You don't have to hold that in anymore. ~Veronica

Given the overall positive impacts of GSI, it is imperative that opportunities of this nature are continually available to African-American girls. Implementing a social transformative STEM curriculum in informal settings is a potential tool for educators to redress the disparities that exist in African-American girls' mathematics and science learning experiences.

References

Aguirre, J., Mayfield-Ingram, K., & Martin, D. (2013). *The impact of identity in K–8 Mathematics: Rethinking equity-based practices*. Reston: National Council of Teachers of Mathematics.

Afterschool Alliance (2011). STEM learning in afterschool: An analysis of impact and outcomes. http://www.afterschoolalliance.org/STEM-Afterschool-Outcomes.pdf.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*, 485–499. https://doi.org/10.1002/tea.20131

Brophy, J. (1999). Toward a model of the value aspects of motivation in education: Developing appreciation for particular learning domains and activities. *Educational Psychologist, 34*, 75–85. https://doi.org/10.1207/s15326985ep3402_1

Eccles, J., Adler, T., Futterman, R., Goff, S., Kaczala, C., & Meece, J. (1983). Expectancies, values and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75–146). Freeman.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Else-Quest, N. C., Concetta, M., & Higgins, A. (2013). Math and science attitudes and achievement at the intersection of gender and ethnicity. *Psychology of Women Quarterly, 37*(3), 293–309. https://doi.org/10.1177/0361684313480694

Evans-Winters, V., & Esposito, J. (2010). Other people's daughters: Critical race feminism and black girl's education. *Educational Foundation, 24*(1/2), 11–24.

Evan-Winters, V. (2011). *Teaching black girls: Resiliency in urban classrooms*. Peter Lang Publishing.

Foley, J. A., Morris, D., Gounari, P., & Agostinone-Wilson, F. (2015). Critical education, critical pedagogies, marxist education in the united states. *Journal for Critical Education Policy Studies, 13*(3), 110–144.

Hulleman, C., Godes, O., Hendricks, B., & Harackiewicz, J. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology*. https://doi.org/10.1037/a0019506

Joseph, N., Viesca, K., & Bianco, M. (2016). Black female adolescents and racism in schools: Experiences in a colorblind society. *The High School Journal, 100*, 4–25. https://doi.org/10.1353/hsj.2016.0018

King, N. S., & Pringle, R. M. (2019). Black girls speak STEM: Counterstories of informal and formal learning experiences. *Journal of Research in Science Teaching, 56*(5), 539–569. https://doi.org/10.1002/tea.21513

Lewis, B., & Connell, S. (2005). African American students' career considerations and reasons for enrolling in advanced science courses. *Negro Educational Review, 56*(2&3), 221–231.

Luttrell, V., Callen, B., Allen, C., Wood, M., Deeds, D., & Richard, D. (2010). The mathematics value inventory for general education students: Development and initial validation. *Educational and Psychological Measurement, 70*(1), 142–160. https://doi.org/10.1177/0013164409344526

Malloy, C. E. (1997). Including African American students in the mathematics community. In J. T. M. J. Kenney (Ed.), *Multicultural and gender equity in the mathematics classroom: The gift of diversity* (pp. 23–33). National Council of Teachers of Mathematics.

Malloy, C. (2008). Looking throughout the world for democratic access to mathematics. In L. English (Ed.), *Handbook of international research in mathematics* (pp. 17–25). Erlbaum.

Martin, D. (2000). *Mathematics success and failure among African American youth: The roles of sociohistorical context, community forces, school influence, and individual agency*. Erlbaum.

Martin, D. (2012). Learning mathematics while Black. *Educational Foundations 26*, 47–66.

McPherson, E. (2014). Informal learning in science, math, and engineering majors for African American female undergraduates. *Global Education Review, 1*(4), 96–113.

Meece, J., Wigfield, A., & Eccles, J. (1990). Predictors of math anxiety and its consequences for young adolescents' course enrollment intentions and performances in mathematics. *Journal of Educational Psychology, 82*, 60–70. https://doi.org/10.1037/0022-0663.82.1.60

Morris, E. (2007). 'Ladies' or 'Loudies'? perceptions and experiences of black girls in classrooms. *Youth and Society, 38*(4), 490–515. https://doi.org/10.1177/0044118X06296778

Morton, C. H., & Smith-Mutegi, D. (2018). Girls STEM Institute: Transforming and empowering black girls in mathematics through STEM. Re-humanizing mathematics for Black, Indigenous, and Latinx students. Annual Perspectives in Mathematics Education, pp. 23–37.

Mutegi, J. W. (2011). The inadequacies of "science for all" and the necessity and nature of a socially transformative curriculum approach for African American science education. *Journal of Research in Science Teaching, 48*, 301–316. https://doi.org/10.1002/tea.20410

National Women's Law Center and Girls for Gender Equity (2015). Listening session on the needs of young women of color. https://nwlc.org/resources/what-young-women-of-color-in-nyc-need/.

National Science Foundation, National Center for Science and Engineering Statistics. (2017). Women, minorities, and persons with disabilities in science and engineering: 2017. Special Report NSF 17–310. Arlington, VA. Available at http://www.nsf.gov/statistics/wmpd/.

Neal-Jackson, A. (2018). A meta-ethnographic review of the experiences of African American girls and young women in K-12 education. *Review of Educational Research, 88*(4), 508–546. https://doi.org/10.3102/0034654318760785

Ryan, R. M., & Powelson, C. L. (1991). Autonomy and relatedness as fundamental to motivation in education. *Journal of Experimental Education, 60*, 49–56. https://doi.org/10.1080/00220973.1991.10806579

Sahin, A., Ayar, M., & Adiguzel, T. (2014). STEM-related after-school program activities and associated outcomes on student learning. *Educational Sciences: Theory & Practice, 14*(1), 309–322. https://doi.org/10.12738/estp.2014.1.1876

Simpkins, S., Davis-Kean, P., & Eccels, J. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42*(1), 70–83. https://doi.org/10.1037/0012-1649.42.1.70

Tate, W., & Rousseau, C. (2002). Access and opportunity: The political and social context of mathematics education. In L. English (Ed.), *Handbook of international research in mathematics education* (pp. 271–300). Erlbaum.

Tesch, R. (1987). Emerging themes: The researcher's experience. *Phenomenology + Pedagogy, 5*, 230–241. https://doi.org/10.29173/pandp15058

Van Manen, M. (1990). *Researching lived experiences: Human science for an action sensitive pedagogy*. State University of New York.

VanMeter-Adams, A., Frankenfeld, C., Bases, J., Espina, V., & Liotta, L. A. (2014). Students who demonstrate strong talent and interest in STEM are initially attracted to STEM through extracurricular experiences. *CBE-Life Sciences Education, 13*(4), 687–697. https://doi.org/10.1187/cbe.13-11-0213

Walker, E. (2007). Why aren't more minorities taking advanced math? *Educational Leadership, 65*(3), 48–53.

West-Olatunji, C., Shure, L., Pringle, R., Adams, T., Lewis, D., & Cholewa, B. (2010). Exploring how school counselors position low-income African American girls as mathematics and science learners. *Professional School Counseling, 13*(3), 184–195. https://doi.org/10.5330/PSC.n.2010-13.184

Young, J., Feille, K., & Young, J. (2017). Black girls as learners and doers of science: A single-group summary of elementary science achievement. *Electronic Journal of Science Education, 21*(2), 1–20.

Yurt, E. (2014). The predictive power of self-efficacy sources for mathematics achievement. *Education and Science, 39*(176), 159–169.

Crystal Morton is an Associate Professor of Mathematics Education in the Department of Urban Teacher Education at IUPUI School of Education. She is also the founder and director of Girls STEM Institute. Girls STEM Institute aims to transform communities by empowering girls of color to become leaders, innovators, and educators who use STEM as a tool for personal and social change. Dr. Morton's scholarly work focuses on secondary mathematics education, emphasizing the role of informal STEM learning in fostering equitable and transformative mathematics teaching and learning experiences. She primarily examines the learning experiences and specifically mathematics learning experiences of Black girls.

Demetrice Smith-Mutegi is an Assistant Professor of Science Education at Old Dominion University in the Darden College of Education and Professional Studies. Her current research interests center on investigating the motivations, beliefs, and experiences of Black students as it relates to STEM and studying factors that impact the career decision-making of Black STEM teachers, including the role of formal and informal experiences. Prior to her work in higher education, she served in K-12 public schools as a STEM educator in North Carolina, Maryland, and Indiana.