Informal Learning in Science, Math, and Engineering Majors for African American Female Undergraduates

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Abstract

This research investigates how eight undergraduate African American women in science, math, and engineering (SME) majors accessed cultural capital and informal science learning opportunities from preschool to college. It uses the multiple case study methodological approach and cultural capital as frameworks to better understand the participants' opportunities to engage in informal science learning or free-choice learning. The article demonstrates that African American women have access to cultural capital and informal science learning inside and outside of home and school environments in P-16 settings. This study adds to cultural capital, informal science learning, and global STEM education research by allowing scholars to better understand how African American women have opportunities to learn about the hidden curriculum of science throughout the educational pipeline.

Keywords

STEM education, African American women, gender studies, global studies, qualitative research, informal science learning, free-choice learning

Informal Science Learning

Informal science learning, also known as free-choice learning, often occurs outside of school settings (Falk, 2005). Free-choice learning is "self-directed learning that regularly occurs in settings like national parks, nature centers, natural history museums, zoos and aquariums, a wide range of community-based organizations, and through the use of print and electronic media" (Falk, 2005, p. 270). Additionally, a growing body of research confirms that the majority of informal science learning occurs in museums and/or science centers in domestic and international settings, including Africa, China, Seoul, Germany, and the United Kingdom (Cainey, Bowker, Humphrey, & Murray, 2012; Dohn, 2011; Gutwill & Allen, 2010; Kang, Anderson, & Wu, 2010; Kisiel, 2005; Lelliot, 2013; Murmann & Avraamidou, 2014; Parker & Krockover, 2013; Shin, Park, & Kim, 2014; Stravrova & Urhahne, 2010). Globally, scholars have also found that parents expose their children to science both inside and outside of the home environment, in places like aquariums, botanical gardens, science centers, and zoos (Alexander, Johnson, & Kelley, 2012; Aubusson, Griffin, & Kearney, 2012; Gutwill & Allen, 2010; Kisiel, Rowe, Vartabedian, & Kopczak, 2012; Rowe & Kisiel, 2012; Zimmerman, Reeve, & Bell, 2010).

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In K-16 settings students engage in informal learning opportunities in laboratories and other settings (Buxton, Allexsaht-Snider, & Rivera, 2013; Samarapungavan, Mantzicopoulos, & Patrick, 2008). Globally, teachers have traveled with students and their families to museums in order to engage them in informal science learning (Crowl, Devitt, Jansen, van Zee, & Winograd, 2013; Karnezoua, Avgitidou, & Kariotoglou, 2013; Kisiel, 2005). Some scholars consider informal science learning to be either entertainment or a form of structured educational learning when it occurs in museum settings (Kisiel, 2005). In addition, parents teach or expose science to their children through hands-on learning projects inside or outside of the home and/or during museum visits to the natural history museums (Alexander et al., 2012; Bamberger & Tal, 2007; Buxton et al., 2013; Rowe & Kisiel, 2012; Wang, Liu, & Zhao; 2012). For instance, Rowe and Kisiel (2012) found that parents taught young children about the types of animals (e.g., fish, mangrove ray, sharks, sea urchins) that they touched in an aquarium. Additionally, Buxton et al. (2013) showed that parents exposed their kids to science through a series of science workshops that centered on laboratory experiments (e.g., Alka-Seltzer rocket) and science careers. However, not all students have equal access to science learning opportunities.

A small number of recent research studies have examined how underrepresented students have opportunities to learn science in the context of informal science learning environments in the United States (Bhattacharyya, Mead, and Nathanial, 2011; Buxton et al., 2013; Simpson & Parsons, 2009; Varelas, Kane, & Wylie, 2011; Wright, 2011). In order to fill a gap in the literature, this study poses the question: How does access to cultural capital provide African American women with opportunities to learn science in informal settings? In order to answer the research question, this article uses the multiple case study methodological approach to demonstrate how undergraduate African American women in science, math, and engineering (SME) majors enjoyed opportunities to acquire cultural capital and to learn science in the context of informal learning environments from preschool to college.

Informal Science Learning in Primary Schools

Recent studies have examined science learning in everyday life, meaning science learning that occurs inside or outside of the home during early childhood (Saçkes, 2014; Saçkes, Trundle, Bell, & O'Connell, 2011; Siry, Ziegler, & Max, 2012; Siry, 2013) or in primary school settings (Alexander et al., 2012; Gutwill & Allen, 2010; Simpson & Parsons, 2009; Varelas et al., 2011; Walls, 2012). Scholars who have studied everyday science learning among early childhood participants found that children construct their science learning and science identities based on their social contexts (Siry et al., 2012; Walls, 2012; Zimmerman & Bell, 2014). This means that the context determines the extent to which students learn and understand science through individual activities and/or group interactions.

The literature on free-choice learning in primary schools mainly focuses on school and home contexts in domestic and international settings. The school context involved students learning about everyday science through class projects (Bulunuz, 2013; Msimanga & Lelliott, 2013; Zimmerman & Bell, 2014). The students were able to apply their knowledge of everyday science to class discussions that focused on meaning-making, logic, and reasoning. Researchers added that focused tasks, connections with students' prior knowledge, school curriculum, life and/or personal experiences made the museum visits and community activities with science more

meaningful (Bamberger & Tal, 2007; Zimmerman & Bell, 2014).

A few studies have examined the connection between race and everyday science learning in primary schools in the U.S., and in Puerto Rico (González-Espada et al., 2014; Simpson & Parsons, 2009; Walls, 2012; Wright, 2011). Simpson and Parsons (2009) conducted a qualitative study on the exposure of African American children and teenagers to informal learning science at Jordan Academy. They found that African American parents wanted their children to learn science from teachers who were "enthusiastic about science, who implemented hands-on instruction which emphasized science content within real-life contexts, and who positively impacted their children" (p. 317). African American and Latino parents also wanted their children to be taught by means of a culturally-relevant pedagogy that focused on developing their racial identities (González-Espada et al., 2014; Simpson & Parsons, 2009).

Outside of the school environment, researchers found that parents exposed their children to opportunities to learn about everyday science in their home environments (Alexander et al., 2012; Gutwill & Allen, 2010; Varelas et al., 2011). In fact, developing an early interest in science influenced children's later engagement in informal science activities (Alexander et al., 2012). These researchers noted that parents cultivated an interest in science by exposing their children to informal learning opportunities, such as those found in museums. However, boys were more likely than girls to have access to such informal learning opportunities. This was true even among boys who were not interested in science. Girls were only given free-choice learning opportunities after expressing an interest in science. Boys had more chances to participate in everyday informal science learning than their female counterparts.

In the same way, African American families helped to engage their children in informal science by participating in everyday science activities at home (Varelas et al., 2011; Zimmerman & Bell, 2014). Science experiments included mixing liquids to create beverages or cooking with household items. For instance, in a study of representations of identities among African American children in science in an urban elementary school, Varelas et al. (2011) found that science learning occurred in relatives' homes. Relatives also served as role models and/or people whom they could observe participating in scientific investigations using products found in the home. These experiences encouraged African American children to aspire to be scientists or engineers.

A study of a Spanish-speaking family's free-choice science learning involved crossing school and home boundaries (Ash, 2004). Spanish-speaking families spoke in both Spanish and English in order to understand science. In this case, informal learning in science referred to learning about science through a coral exhibit in the museum. The family had prior knowledge of science acquired through viewing pictures and other objects. When looking at the coral museum exhibit, the adult family members conversed with the children using both English and Spanish. The adult members readily asked questions of the museum experts. This experience socialized the children to ask similar questions in order to obtain important information about the coral exhibit.

Informal Science Learning in Secondary Schools

Few studies have focused on the everyday science learning experiences of students in secondary schools (Bhattacharyya et al., 2011; Dohn, 2011; Kong, Dabney, & Tai, 2013; Lelliott, 2013; Scott, 2014; Şentürka & Özdemir, 2014). In middle and high schools, the context of learning everyday science was a museum, a

summer program, a science center, or a summer camp. In the museum setting, Dohn (2011) also found that having a controlled environment can enable students to better understand science. For instance, in the aquarium environment, students learned about everyday science through hands-on experiences, innovative and/or unexpected activities. These experiences created situational interests in science among the high school students.

The review of literature above reflects what we know about informal science learning during early childhood throughout high school. However, there are few studies that have examined the middle school, high school, and post-secondary experiences of those who later became scientists. Additionally, few scholars (McPherson, 2012; Wright, 2011) have focused on informal science learning among girls, women, and minorities in home and/or school settings as they move through the educational pipeline. Hence, this study will attempt to fill this gap in the research on free-choice learning, more specifically among African American girls and women.

Cultural Capital

Understanding African American women's exposure to informal science learning begins within their homes. The home environment is the foundation for early-life exposure to science outside of primary and secondary schools. This exposure to free-choice learning experiences and resources is best conceptualized as cultural capital (McPherson, 2012). Cultural capital serves as the hidden curriculum for practices inside and outside of the traditional middle-class culture (Bourdieu, 1984: Feinberg & Soltis, 2009) or nontraditional cultures (Yosso, 2006).

The early conceptualization of traditional cultural capital involved a class-based study of the cultural tastes (e.g., music, art, museums) of people in the upper social classes (Bourdieu, 1984). However, this cultural capital framework omitted an analysis of race and gender (Dumais, 2002; Lareau, 2003; Lareau & Weininger, 2003; Mickelson, 2003; Yosso, 2006). Dumais (2002) connected cultural capital to gender, and observed that mothers transmitted cultural capital to their children. She found that cultural capital may be used inside or outside of classrooms. Girls showcased their cultural knowledge by scoring high marks in classes, and they participated in cultural activities outside the classroom such as dance lessons, art lessons, and music lessons, reading at the library, concerts, and museum visits. On the other hand, boys might not fully display their cultural knowledge by participating in cultural activities outside of the classroom.

Critical race scholars (Mickelson, 2003; Yosso, 2006) added to the debate and discussion on the connections between race and cultural capital by acknowledging that African American students aspire to pursue their dreams despite obstacles, which is the essence of aspirational capital, a non-traditional form of cultural capital. Yosso (2006) used a critical race theory perspective to critique Bourdieu's model of cultural capital for omitting the discourse of race. She said that African American communities acquire cultural wealth through specific types of capital, including "aspirational, navigational, social, linguistic, familial, and resistant capital" (Yosso, 2006, p. 176).

Scholarship in the field of sociology of education has contributed research to the racialized discussions of cultural capital in primary and secondary settings. For example, Lareau (2003) observed that White and Black middle-class parents made efforts to cultivate the talents of their children by engaging them in activities that allowed them to practice those talents. On the other hand, children from working-class and poor families participated in natural growth through informal play activities, which allowed them to become more independent (Lareau, 2003; Lareau, &

Weininger, 2003). This research highlights the small number of research studies that connect cultural capital to racial groups.

Cultural capital has also been used as a deficit model to explain why middle class people use specific cultural tastes to socialize children and teenagers for the middle class lifestyle while other parents failed to use those cultural tastes when socializing their children (Winkle-Wagner, 2006). Unlike previous research, Banks (2009) used a strengths-based approach to better understand African American women's persistence in college. She confirmed that African American women make use of various forms of cultural capital (e.g., history, resources, family) that contributes to their persistence in college. Waites (2009) found that African American families had legacies of using family members as resources for support for childcare and care of elderly family members, known as intergenerational support. It supports the strengths-based approach within the field of social work.

Similarly, this research study uses a strengths-based approach to apply the framework of cultural capital to improve our understanding of the opportunities that African American women have to learn science in informal settings throughout their lives. For example, science equity research has reported disconnections between students' culture, the science curriculum and science pedagogies (Lee & Luykx, 2006; Southerland, Smith, Sowell, & Kittleson, 2007). The science curriculum often centers on a western model that devalues the work of non-western scientists (Lee & Luykx, 2006). Lee and Luykx (2006) state:

When students do not share the 'culture of power' of the dominant society (e.g., Western science), teachers need to make [sure] that culture's rules and norms [are] explicit and visible so that students can learn to cross cultural borders between their home environment and the school environment (p. 90).

These hidden rules and norms can be described as a form of hidden curriculum, and this has been noted in cultural capital research (Feinberg & Soltis, 2009). Providing access to information (e.g., cultural capital) allows for students to become knowledgeable about the rules and norms "for classroom behavior and academic achievement" (Lee & Luykx, 2006, p. 76). In addition, having access to knowledge of the science culture[1] provides students with opportunities to learn and perform academically if they obtain the same exposure to the science culture as their peers. Furthermore, students who learn the values, rules, and regulations by means of explicit instruction via socialization, learn how to communicate using scientific terminology, understand scientific texts, and engage in projects in research labs (Southerland et al., 2007). This can make it easier for students to navigate the science culture and have more opportunities to learn in science communities.

The above review of literature shows that cultural capital provides people with access to learning about science. However, what is still lacking in the informal science literature is a connection to the hidden curriculum that will allow African American women to enjoy opportunities to learn science in informal settings through exposure to science-related activities as they matriculate through the educational system. The use of the cultural capital framework is thus appropriate for this study for the purpose of examining access to informal science learning.

Methodology

Data Collection

This research sample was pulled from a larger study on the persistence of undergraduate African American women in hard science majors (e.g., biology, engineering, mathematics, and

business) at a predominantly white institution. The National Science Foundation (2009) defines the hard sciences as including: biology, computer science, earth science, atmospheric science, oceanography, and physical science (e.g., chemistry, astronomy, physics). This study included business as a hard science major, because it requires a thorough understanding and application of mathematical concepts (McPherson, 2012).

Sample

The multiple cases were the African American women who persisted in hard science majors. College persistence is defined as students making progress towards a degree (Pascarella & Terenzini, 2005). In this study, success by means of persistence is determined by engagement in upper-level coursework as an upperclassman (e.g., junior or senior) with an undergraduate student status. The eight hard science majors selected for participation in the study were: (1) women who self-identified as African American or Black with upperclassman status based on credit hours, (2) women who were also in hard science majors at Town University (psuedonym), (3) women between the ages of 19 and 23. These African American women were purposefully chosen to participate in the study.

Interviews

Data collection consisted of four structured interviews and journal entries. The interviews lasted from 8 minutes to three hours. The researcher asked questions that focused on their experiences in math and science in primary, secondary, and postsecondary settings. The interviews included questions about how family background impacted their access to opportunities to learn about science and their access to cultural capital.

Research Setting

This multiple case study was completed at a predominantly white institution, Town University in Maytown. Town University was chosen because of the undergraduate student population. Town University is a research-intensive institution that serves over 30,000 undergraduate students (U.S. Department of Education & National Center for Education Statistics, 2010). There are slightly more men (over 55%) enrolled at the institution than women (about 45%). The majority of students are white (about 60%), about 28% are minority students, about 9% are immigrants, and about 3% are students of unidentified racial backgrounds.

The demographic data suggests that Town University is a predominantly white institution with a small pool of minority students matriculating at the undergraduate level. In addition, fewer minority students and women are enrolled in SME majors at this university at the undergraduate level in comparison with their white male and international counterparts (U.S. Department of Education & National Center for Education Statistics, 2010). Moreover, the data show that the attrition of women and minority students in science occurs more frequently during the freshman and sophomore years than during the junior and senior years. This might be attributed to the persistence of women and minority students by way of commitment or a desire to avoid hard science majors.

Data Analysis

The electronically recorded interviews were transcribed verbatim. The data were analyzed by question using data displays and memos to derive meaning and find themes. The qualitative data analysis program, Maxqda was used to code the data and develop themes consistent with qualitative data analysis (Lofland & Lofland, 1995). In qualitative

research the results show that meaningful patterns and trends can be found in the data, and these patterns and trends are presented below.

Findings on Informal Science Learning in Home and School Contexts

This section reports the findings concerning African American women's engagement in everyday learning of science through traditional forms of cultural capital at home, school, and in museum settings. This section begins with a discussion of the traditional forms of cultural capital that African American women in SME majors used to help themselves persist in SME fields from primary school through college.

Informal Science Learning in Primary Schools

Early Socialization

Research shows that some undergraduate African American women who were committed to SME majors became interested in science or mathematics as early as preschool and as late as elementary school (Brown, 2011; Jordan, 2006; McPherson, 2012; Warren, 2000). In the current study, African American women identified informal science learning as a form of cultural capital acquired in the home or school during preschool or elementary school. When asked to disclose their early memories of science or math, African American women specified their home environments, namely family members, as providing them with access to informal science learning through role models early in life.

> It was before even I started school. My mom, she was in nursing school. She started school when she had all of us, me and my brothers. She also worked in the hospital before she got her degree. There was 'the bring your kids to work day'. She brought us to the hospital. . . They let us play with the stethoscopes. I thought that I wanted to be a nurse from that point [on]. Probably, because my mom wanted to be a nurse too! (Shannon, biology major)

> Probably around fourth grade... The first thing that I can remember...my brother is two years older than me. So he was always two grades above and when he learned something in math he would always come home and say *Lara*. He would be doing problems on a sheet of paper. I would look at it and it would be kind of interesting. Ever since then, I have always been ahead in math, because of him. I liked it and I kept on liking it. I just continued with it. That is probably the first thing and the main thing that has kept me in math. (Lara, math major)

Outside of their homes, schools exposed African American women who were children at the time to informal science learning through projects and fieldtrips to museums. These trips to museums provided them with access to cultural capital and further socialization in SME fields through learning about science in these settings. When asked about their early memories of science, Rachelle responded:

> Insects and books. I did not like that aspect of science at all. I rarely looked at them. After that I guess. . . simple math and long division. . . For the insects, since I was younger, I went to preschool, pre-K, so three [years old]. We did mini-science [projects] there and I knew that I did not like insects. . .

In a manner similar to Rachelle, Briana stated that elementary school gave her an

opportunity to learn about science. When asked about an early memory of science, she stated:

> The earliest that I can think of was our field trip with the gifted program and going and pretending like you were on a spaceship. We had head controllers and we worked these different machines. It was just so cool to me. I had such a blast. I had so much fun that day. I remember just loving it.

This section makes it clear that the home environment, early childhood and/or elementary schools were the foundation where African American females began their informal science learning. These educational spaces were socialization tools that sparked their early interests in science and promoted their continuing interests in science as they moved through the educational pipeline.

Summer Camps

In middle school, informal science learning that became cultural capital for African American women was acquired in summer camps. This is reflected in the narratives below.

> My mom she pretty much put me in summer camps. Those trips always took me places, including museums. Then sports. . . there was just a mixture of things. (Lara, math major)

> A couple of years, I went to summer school, but it wasn't summer school to make up classes. It was pretty much a summer camp with the school. It was a half-day school type of thing. They made it more fun so kids would want to go. I remember taking most of the trips to museums during the summer school portion. (Shannon, biology major)

> In first grade was when they started to really say, 'She's a smart girl.' My teacher recommended me for this summer program for gifted kids. . . I'm glad that I did it. . . It was at the botanical garden in South West City. I went there every day and would hang out at the botanical garden and do different experiments and things. . . (Jennifer, math major)

Research on informal science learning among African American children (Bhattacharyya et al., 2011; Simpson & Parsons, 2009; Varelas et al., 2011) and adolescents globally (Kang et al., 2010; Kong et al, 2014; Oliver & Venville, 2011; Shin et al., 2013) is consistent with the above excerpts to the effect that African American girls had opportunities to learn about science on an informal basis through trips to museums and participation in summer enrichment camps. These opportunities allowed for them to develop cultural tastes similar to those of the middle class, as described in Bourdieu's traditional cultural capital framework (Bourdieu, 1984).

Science Fairs

In elementary and middle school, the teachers of African American girls provided them with access to cultural capital by exposing them to informal science learning through science fairs. Narratives regarding this point appear below.

> . . . We had to invent something. So, I invented a remote [control] finder, but I basically put a doorbell on it. So that when you need to look for it, you push the button and there it goes. (Patricia, business major)

> I remember I did this one with soap. . . I think it was electricity. . . If you put water and then put pepper in it, and then you put static on a plastic comb, you can put

> the comb then close to the water and it'll affect the water. So I remember that was one. I did the volcano thing. I did about three or four [science fairs] when I was in middle school. . . When I did really well in the middle school science fair, I got an award. . . The award allowed [for] me to go on to do this science program. . . It was again, another thing during the summer [and it was] during the day. . . (Jennifer, math major)

In a manner consistent with prior research (Bhattacharyya et al., 2011; Simpson & Parsons, 2009; Varelas et al., 2011; Walls, 2012; Wright, 2011) regarding informal science learning for African American children and adolescents, this section showed that African American girls had opportunities to learn about science on an informal basis through science fairs. This scholarship also supports global research (George, 2013; Murmann & Avaamidou, 2014) on science instructors exposing students to science centers and/or a culturally relevant pedagogy when teaching science in the Caribbean and Copenhagen. Thus, U.S. teachers may be a powerful resource for encouraging an interest in science among African American girls and/or providing them with opportunities to engage in informal science learning inside or outside of school.

Exposure to Science and Math Through Families

Families provided African American girls with access to cultural capital through free-choice learning in elementary and middle school as well. Some examples are below.

> We find that kind of stuff interesting, and so I bring home something, and he [my dad] just soaks it up. . . He's helped me with it and then would take it further about what to do with this, and he was the one that would buy the 'Let's think about this'[books]. They sell books with different types of experiments that you can do, which is where I got some of my science experiments from. He was the one that brought them home, and [my brother, him,] and me would go through that book and do experiments just for fun. [It was] not even for the fair, some, just on our own. We'd test different things, and we did, I think, some rainbow thing [and], prisms. . . (Jennifer, math major)

> My mom would always take me and my brother to different types of museums. . . The camps that I went to they also went to museums, the Children's Museum of Science, the Animal Aquarium. I have always been at museums and aquariums. Also my uncle, my cousin's dad, he would take us places too, [such as the] museums downtown. (Lara, math major)

> We didn't have any of that. I did not have any of that in school. I cannot remember the last time I have been to school on a field trip. It had to [be] before junior high when we went to a field trip for a museum. I remember liking the Children's Museum of Science. I remember little things that we did there, but that is about it. . . My parents took me. I do remember going there with school. I mainly remember it, because my grandmother has the newspaper clippings from me being in the museum. I remember running around and the thing where you can whisper your voice and we heard it on the other side of the room. (Simone, engineering major)

The above narratives provide a more detailed explanation of informal science learning by showing how African American parents are involved in helping their children to learn about

science at home and elsewhere. Parents are important because they encourage interest among the talented pool of underrepresented scholars in SME fields as early as preschool and as late as elementary school. These findings add to prior research, which showed that African American parents were involved in their girls' learning inside and outside of schools (Bhattacharyya et al., 2011; Brown, 2011; Jordan, 2006; McPherson, 2012; Warren, 2000). Parents play a major role, but not the one and only role, in what their children learn about science on an informal basis.

School Field Trips

School field trips to museums also served as forms of cultural capital that expose African American women to informal science learning.

> In elementary school, every year we would take field trips to the same museum in Central City. [One museum] . . . is similar to a History and Anthropology, [or an] Archaeology museum. A lot of the exhibits are based on archaeological finds. I went to those museums numerous times in my life both in and out of school. For example, my mom would have her sister come down with her kids and we would all just go to the museum one day. So, I got a lot of exposure to science there. (Ashley, biology major)

> When I was younger, I started going to museums through this after school program and summer camps. We used to take field trips during the school years. . . Of course we have been to museums. It is for astronauts. They put us in this astronaut thing and we had to perform some mission and all of the steps, which was really fun. I really liked that. . . (Patricia, business major)

> [We went to] the Children's Museum of Science. Then we would go to the aquarium. We did not go to the art museum, not in elementary school. . . From what I remember, what I liked most. . . [is that] they had an interactive area for younger kids. You could do a lot of stuff, hands-on activities. It was not like pointing and looking at things at what they had displayed. (Shannon, biology major)

Attendance at museums provided African American girls with both hands-on interactive informal science learning experiences and educational experiences, similar to that of students informal learning in Turkey pre-school classrooms and science festivals in England (Bultitude, McDonald, & Custead, 2011; Bulunuz, 2013). This differs from the sort of informal learning research typically found in museums that provide entertainment or educational experiences in the U.S. (Gutwill & Allen, 2010; Kisiel, 2005).

Student organizations

In primary schools, student organizations provided cultural capital by supplying African American girls with access to free-choice learning opportunities. Examples appear below.

> I was in [the] Girl Scouts, and I remember we went there [the museum] a couple times for that, too. I think [that it was in] fourth and fifth [grade] . . . It was okay. (Jennifer, math major)

> In middle school, I was in the National Junior Honor Society. . . We did volunteer work. It was not too much school-related stuff. It was pretty much like these are the scholars of the school. We worked on community service [projects]. [As] part of

> that we did tutoring for younger students, in whatever subjects that they needed help in. Mostly, it would be math. (Shannon, biology major)

Thus, student organizations in middle school provided African American girls with opportunities to learn and engage in informal science learning through museum attendance and/or tutoring others. These findings support scholarship on Chinese students who have access to science through free-choice learning opportunities in science clubs in China (Wang et al., 2012),

Informal Science Learning in Secondary Schools

African American women's exposure to informal science learning opportunities in high school consisted of tutoring, student organizations, and museums.

Tutoring

Tutoring was one form of informal science learning that helped African American women teach other students about mathematics or science. When asked about opportunities to informally engage in science or math, engineering major, Simone responded "I had a job tutoring one summer in math...I tutored 8th graders and then I tutored freshmen and sophomores in high school... A lady that was the advisor for my service organization told me [about it]." This passage shows that everyday learning about science occurs outside of classrooms where students learn about mathematics and/or science. Hence, informal learning can occur in the form of instruction by students. In this sense, the former learner becomes the instructor and shares their knowledge of science and/or math with other learners. This learning can be seen as a traditional form of cultural capital in which someone helps provide knowledge, or 'hidden capital', in order to help others navigate through mathematics and/or science content in K-12 settings.

High School Student Organizations

Student organizations and clubs also exposed African American female teenagers to free-choice learning by having them work with peers in high school. These can be seen as a form of traditional cultural capital. Following are some narratives on Rachelle and Shannon's experiences with science and math organizations.

> I was a part of the. . . science club. I was a regular participant. We did a few conferences. So, I went to those. Every other week, we would talk about something interesting. Our teacher would show us an experiment that she had. That is about it. [The conferences] . . . were in-state at other schools. I don't remember which schools. Some people did an egg drop. I think that I did a mousetrap racecar just measuring how far they went. [They were] just little competitions between everybody. (Rachelle, biology major)

> I was in Math Champs. . . It is a group for students who are interested in math. You compete against other schools. We met once a month. We would go to competitions and compete with other schools doing math problems. It was not a buzzer type [of] competition, but you would take a test. They would see what school got the highest scores. We had a regional competition that was near. It was 15 miles away. We made it through the regional [competition], we went to state. So, we went to the state competition that was 30 minutes away. It was still in Central City. . . That was my junior year. (Shannon, biology major)

The above excerpts make it clear that student organizations served as hidden forms of traditional cultural capital for socializing African American female teens for advanced studies in mathematics or science in high school, college, and their future careers. This section showed that African American females learned about science outside of classrooms with peers in the same high school clubs or organizations. These findings support scholarship on student organizations that socialize students to pursue education and careers in STEM fields (Dabney, Chakraverty, & Tai, 2013; Scott, 2014; Wang et al., 2012).

Museum Visits

In high school, some African American females went to science museums and/or entered science fairs, which gave them cultural capital. Museums also exposed them to informal science learning prior to majoring in SME majors in college. Simone describes her experience below.

> I went to the museum every once in a while. Usually, it was a free day in the summer. I went to summer camps, but they were not revolved around school. . . I think that I went to a field museum once or twice.

This finding is supported by research that tied museums (Bourdieu, 1984) and science activities to cultural capital. Other scholars (Dohn, 2011) have similarly shown that museum visits provided high school students with opportunities to learn about science, which is another example of informal science learning that occurs in high school.

Informal Learning in College

In college, traditional forms of cultural capital that provided African American women with access to informal science learning opportunities that included research seminars, research projects, research conferences, and student organizations.

Research Seminars

Briana's narrative below discusses her attendance at a research seminar at Town University. She states:

> It was here. It was something about sub-polarization, so how cells grow and a particular signaling, pathway. It was very detailed, very biology. . . Something that was very over my head. I just wanted to go, because I had never been to one of these. . . I think that I had to do it for a class or something. So I went there, I went up to the professor... It was a good talk. I was just trying to talk to her, [and] compliment her on it.

This passage reflects that informal science learning in college offers African American female students' opportunities to learn and engage in dialogues about science.

Research Projects In addition to research seminars, three African American women participated in research projects, which provided them with opportunities to acquire free-choice learning. Ashley and Briana describe their research experiences as follows:

> I am currently doing research with a grad student who is under a professor. . . It is going good, very well. The projects are almost done. I am kinda upset about [that], because I wanted to be under her during the summer. . . She is studying the effects of BPA on the levels of LH and FSH. . . BPA, I don't know what it technically stands for. It is usually found in plastics. If you buy a water bottle or something, it will say no BPA. It is supposedly linked to adverse effects with the pituitary gland and hormones. So LH

> and FSH are hormones produced in the pituitary glands. We are taking mice and we are doing different experiments and there are different levels of LH and FSH. . . . We are looking at BPA. (Briana, biology major)

> [For the senior thesis,] the big thing was learning how to write scientifically. So she [the research professor] has been continuing to give me help on 'how to' do that, so that had definitely work and just being able to apply the different things that I have learned to what I am doing in lab. . . (Ashley, biology major)

In addition, the culture of the research lab matters, particularly for underrepresented populations in SME fields. When asked about comfort in the research lab, all of the women felt welcome. This is shown in Ashley's narrative below.

> The first time I got there, the professor was really helpful. She was always there; she is in her office just doing work or whatever. . . Then the grad students, [and] technicians that might have been there were all very helpful. You could ask them questions and they were willing to answer them. The grad student that I have been working with for the last few years is really good.

This excerpt shows how informal science learning in college occurs in research labs. It also discusses the warm and welcoming culture of some research labs. This socialization beyond classroom walls is what helped these women feel comfortable while engaging with peers and/or professors who were members of science communities at Town University. This is different than research lab experiences in which women believed they were in 'chilly' spaces (Ferreira, 2002; Justin-Johnson, 2004).

Research Conferences

A handful of African American women attended conferences or seminars in STEM fields. For instance, Simone recalled a conference where she presented research. She explained:

> I've done the McNair Research Conference. I've done two of those, well, three. . . [In McNair] I did a risk assessment. . . of hazardous waste. . . [I examined] when trains are carrying hazardous waste [and] how likely are they to get [into] an accident and how many people will they affect. [I also explored] . . . what cities [ran] the most risk of that. . . It was kind of the start of one of my professors, a professor I've worked with since freshman year. One of his grad students was about to start the project, and I just did an overview of it. . . I worked with the professor from freshman year to second semester of my freshman year to the end of 2010. (Simone, engineering major)

This example shows that informal science learning occurs in college and during research presentations at research conferences in which students inform other conference attendees about their research experiences and findings from research conducted under the guidance of a professor. The learning that occurs can be thought of as a traditional form of cultural capital, and more specifically as a 'hidden curriculum' intended to prepare them for graduate school and/or the workforce.

College Student Organizations

This section displays narratives of African American women who acquire cultural capital through informal science learning through participation in student organizations.

> Just the National Society of Black Engineers. . . I was secretary last year, and I serve on committees, [and participated in the] pre- and post-college initiative. . . So, getting students to come visit the school [who are] interested in engineering. We tutored at [a local middle school]. (Simone, engineering major)

> For science, I am in [an international] club, but we are all science majors. We volunteer, so we don't do science activities. . . It is pretty much their effort to get medical attention to kids in underserved countries. We are all bio majors or Pre-Med. (Shannon, biology major)

Student organizations provided African American women with access to learning opportunities in free-choice learning in science environments. They may also promote their persistence in college in SME fields. In conclusion, informal science learning occurs in college settings, such as research seminars and research labs. Research conferences and student organizations exposed African American women to free-choice learning outside of the classroom.

Discussion of Findings on Informal Science Learning in P-16 Settings

African American women have access to traditional forms of cultural capital in P-16 settings. This study's findings contradict scholars who have posited that girls have fewer opportunities to acquire informal science learning opportunities (Alexander et al., 2012; Heppner, Wao, & Lee, 2010; Hill, Corbett, & St. Rose, 2010). However, the results are consistent with prior research (Saçkes, 2014; Saçkes et al., 2011; Siry, 2013; Siry et al., 2012; Walls, 2012) on informal science learning, and early exposure to traditional forms of cultural capital such as trips to museums and role modeling in the home.

These findings also contribute to our gendered and racialized understanding of informal science learning opportunities and cultural capital for African American girls in primary and secondary schools. In K-12 settings, African American girls acquire cultural capital and access to free-choice learning of science in the home environment, museums, science fairs, student organizations and clubs in primary and secondary schools. However, in high school African American female teens had fewer opportunities to engage in everyday science experiences at home like those provided in the home environment in primary school settings. These findings confirm previous research which shows that students in primary and secondary school settings were exposed to informal science learning in museums and/or the home across the globe (Alexander et al., 2012; Buxton et al., 2013; Crowl et al., 2013; Gutwill & Allen, 2010; Karnezoua et al., 2013; Lelliot, 2013; Murmann & Avraamidou, 2014; Simpson & Parsons, 2009; Varelas et al., 2011).

Finally, this research adds to the literature by showing how cultural capital that is transmitted to African American girls by means of informal science learning in college consisted of involvement in student organizations, research projects, seminars, and conferences. African American women also had access to traditional forms of cultural capital (e.g., research, student organizations) at a PWI, which contributed to their engagement and persistence. These results confirm Banks' (2009) findings that by providing African American women with access to traditional forms of cultural capital at a PWI contribute to their persistence in college.

Conclusions, Limitations, and Areas for Future Research

Cultural capital provides African American women in SME majors with opportunities to engage in informal science learning. Early exposure to informal science learning in primary schools and/or the home can help prepare African American women to actively engage in science and/or mathematics in high school and college settings. This research adds to cultural capital and free-choice learning research allowing scholars to better understand how African American women have opportunities to learn about the hidden curriculum of science through informal science settings as they move through the educational pipeline. We also understand how teachers and parents can expose future African American women to traditional cultural capital outside of home and school environments, which is consistent with informal learning among students across the world.

Limitations

This research was a qualitative study with only eight participants, and the findings cannot be generalized to all populations of African American women in SME majors. Populations such as teachers, parents, and community members were excluded from this study. So, we do not have a holistic picture of how informal science learning occurred within multiple contexts (e.g. home, school, neighborhoods) among different stakeholders such as peers, parents, teachers, administrators, or community members.

Areas for Future Research

Future researchers should consider conducting a replication of this qualitative study in domestic and international settings. They should conduct a quantitative and/or mixed methods study of one population, or multiple underrepresented populations in order to determine how cultural capital influences underrepresented students' access to informal science learning opportunities. Researchers might consider using multiple types of stakeholders, including peers, parents, teachers, and/or administrators, across the educational pipeline and around the world.

Implications for Practice

In primary schools, student organizations and teachers play a role in the socialization of African American girls in SME majors. So, both stakeholders can provide good resources for informal learning in science. Globally, teachers who use culturally relevant pedagogies combined with informal science learning can connect everyday experiences into teaching and learning of math and science. This might help increase the talent pool of girls and underrepresented students involved in STEM around the world. In elementary and middle school, student organizations may be a means of encouraging and socializing girls and racial/ethnic minorities to pursue the study of science and mathematics in college and beyond, and prepare them for careers in science and/or mathematics. Parental and school museum visits may encourage girls and minorities around the world to study mathematics and/or science in high school and beyond. Finally, in college professors' research labs, seminars, and culturally relevant pedagogies can engage more girls, African American girls and women, and minorities in STEM. Moreover, college students' exposure to domestic and international, science centers, volunteer opportunities in the community, and student organizations can facilitate the retention and persistence of African American women in STEM majors by making them feel included in the science culture. These informal learning

opportunities can also teach and socialize them to adjust to the 'hidden science culture' that involves students learning about science beyond classroom walls in domestic and international settings.

Notes

1. The science culture revolves around the teaching and learning within the field through a Western mode of thought (Harding, 2006; Lee & Luykx, 2006; Seiler & Gonsalves, 2010). In the teaching of science, students learn about the contributions of Western scientists and less about the ideas and thoughts of non-Western scientists.

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