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ORIGINAL PAPER

Disrupting deficit narratives in informal science education: applying community cultural wealth theory to youth learning and engagement

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Abstract
Informal learning organizations such as museums, zoos, aquaria, gardens, and community-based organizations are often positioned as having programming that fill a void that may exist in the lives of youth participants. Often these institutions do not recognize the assets that youth gain from their own homes and communities and bring to bear in these programs and that contribute to their success and persistence in STEM and academics. In this paper, we problematize the prevailing deficit-oriented approach to STEM enrichment programs for youth who are underrepresented in STEM. Drawing from Tara Yosso's theory of community cultural wealth, we describe the STEM identity and trajectories of three individuals as they navigated a long-term, museum-based, informal science learning program. Using Yosso's framework, we describe the capital that youth brought into the program and the ways that they leveraged this capital as they moved from middle to high school, and into their postsecondary studies and early careers in the sciences. Furthermore, we describe how their existing capital intertwined with capital they gained from the museum program in ways that fostered persistence and achievement in science.

Keywords Informal science education · Museum education · Community cultural wealth · Out of school time · STEM career

In the USA, the National Science Foundation has made a priority of "broadening participation" in STEM; this means increasing the numbers of women, African–American, Hispanic, and Native-American people in STEM majors and careers (National Science Foundation 2008; Clewell and Fortenberry 2009; National Academies of Sciences, Engineering,

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and Medicine 2016). Accordingly, many out-of-school time (OST) science programs have been designed with this notion in mind. However, despite efforts by both formal and informal science institutions to improve representation in STEM, data show that inequities persist (Landivar 2013a, b; National Science Board 2016). This leads us to question—why is there still underrepresentation of many historically marginalized groups despite these efforts? While museum and informal science programs have certainly contributed to broadening diversity in STEM (e.g., Winkleby, Ned, Ahn, Koehler and Kennedy 2009; Habig, Gupta, Levine and Adams 2018; Blanchard, Gutierrez, Habig, Gupta and Adams 2020), it is important to study these and other programs because as well-intentioned as they are, systemic inequalities have structured and continue to structure many of the practices that persist in such institutions (Castagno 2014). For one, many programs for broadening representation are often designed with an unconscious "deficit" approach in mind. Well-intentioned staff and leaders of these institutions think they are doing work for equity, access, and diversity, yet still might enact practices that promote implicit biases (Staats 2013). This might result in the assumption that participants are bringing very little, if anything, in terms of any forms of capital (e.g., social, academic/intellectual) to the program (Baldridge 2014).

In this paper, we challenge existing notions of diversity and broadening participation in science by positioning the cultures that youth bring to the informal science programs as assets. We describe how youth leveraged their own capital allowing them to navigate the program in ways that afforded them success and access to different forms of capital within the informal learning program. We use this as a basis to begin to challenge both our own thinking about informal science learning program design and a call to the larger ISE field to reexamine notions of diversity and equity in their own programs.

Those who create and teach in OST STEM programs are often not representative of the audiences they aim to serve. For example, a 2011 survey from the American Association of Museums (Katz 2011) found that while the number of males and females were about equal, 79% of the workforce was White. A more recent survey of New York City (NYC) cultural institutions (National Center for Arts Research 2019) found that Whites represent 66% of museum staff even though they comprise 32% of NYC's population. In contrast, 10% of NYC cultural workers identify as African-American (22% of NYC's population); 11% identify as Hispanic (29% of NYC's population); and 6% identify as Asian (14% of NYC's population). Moreover, educators in these spaces come from varying academic backgrounds and many have not completed teacher education programs where they may have participated in discussions on how people learn and the best ways to engage learners. The lack of professional development available for OST staff is further exacerbated by the fact that culturally responsive teaching is often misunderstood, and best practices are likely not employed for both planning and delivering learning experiences (Tran, Gupta and Bader 2019).

The notion of colorblindness, the idea that individuals are not defined by race and that everyone is equal, is a dominant ideology of Western culture, and one that largely ignores the relationship between race and power (Bloom, Peters, Margolin and Fragnoli 2015). Even in informal spaces that frequently enact more learner-centered pedagogies, there is little examination of the relationship between race and power in the context of program design. Within the framework of multicultural education, Angelina Castagno (2013) describes this as "powerblindness" and suggests that it plays a role in the protection of the status quo. Powerblindness takes the notion of colorblindness one step further in that it denies that there is an unequal distribution of resources and access to power. This denial of power-related difference is evident in informal science education (ISE) where programs

are often structured to increase diversity, yet they are often not structured to recognize the embedded power and racialized structures in ways that afford students agency in transforming them to be more authentically inclusive—that is, creating learning experiences that address issues of equity in the context of the cultural practices, values, and beliefs representative of our society (Alston and Cantor 2014). We, the authors, pause here to note that we do not view physical blindness as a deficit within the constructs of ableism; however, for the purposes of our argument, we use the concepts of "colorblindness" and "power-blindness" to illustrate how ISE programs might not be designed to recognize or address structural inequalities. Instead, ISE programs are often structured around diversity-as-niceness, which Castagno (2014) describes as diversity that is "engaged in nice ways that fail to work toward equity and ultimately reify whiteness" (p. 2). Diversity can be extended to be thought of as charitable and good; doing good things for children of color while not challenging the very basis of inequity. This means creating opportunities for racialized students, defined as students who experience barriers rooted in historical and contemporary prejudice of society (Gonzalez-Sobrino and Goss 2019), to engage in science without confronting the underlying structures that present barriers for equitable engagement with science.

ISE programs are designed with good intentions. For museums in particular, "enrichment" programs have been historically designed to expose children to experiences that they were lacking; "early Museum educators and leaders viewed urban life as uninspiring, and fraught with cultural deprivation and viewed themselves in the superior position of being able to provide poor urban students with the experiences they were missing" (Adams 2007, p. 406). Children were described as having little experience and "meager opportunity for general information" (Sherwood 1927 in Adams 2007). This deficit narrative continues to underlie program design where many ISE providers assume that students are entering the programs with low levels of knowledge and skills needed to navigate education in general and more specifically, science education.

In order for us to move toward authentic spaces of equity—i.e., "environments that are deeply responsive to students' needs and strengths, and rooted in a critical, historical analysis of educational and social inequity" (Vossoughi, Escudé, Kong and Hooper 2013, p. 1)—we need to design programs from asset-oriented perspectives. This means "building on the funds of knowledge" of diverse students (Rahm 2016, p. 73) and incorporating a "strengths-based model" (Rahm and Moore 2016, p. 797) to leverage youths' existing capital toward persistence and success in science. As an act of authentic equity, Tara Yosso (2005) invites us to think about youth as having capital in the form of community cultural wealth (CCW). This notion builds on the Bourdieusian ideas that dominate thinking and design around programs for youth; the need for them to obtain certain sanctioned forms of capital (Bourdieu 1986). Traditional capital theory states that since we are shaped by the sociocultural influences in our lives, we either have or do not have certain kinds of knowledge, or capital, needed to move from our current situation to a better situation (Bourdieu 1986; Coleman 1988; Lin 1999, 2000, 2002). Thus, capital in the form of social networks of relationships, academic knowledge, and financial resources become currency that one can use to move from a lower socioeconomic status to a higher one or even to maintain a higher status. Yosso (2005) challenges the traditional interpretations of Bourdieusian cultural wealth whose theoretical contributions have led to, in some cases, a deficit-oriented way of thinking, which has become a powerful force in shaping how both formal and informal learning organizations construct and enact their program designs. Institutions of learning conflate constructs of race and socioeconomic status and make assumptions that people of color (regardless of socioeconomic status) are disadvantaged because they lack social

capital. Yosso (2005) outlines six forms of capital that comprise the CCW framework: aspirational capital, linguistic capital, familial capital, social capital, navigational capital, and resistant capital (Table 1). She posits that acknowledging and celebrating these forms of capital could transform how learning experiences are structured. To date, Yosso's ideas have mostly been applied to STEM studies of higher and formal education (e.g., Oropeza, Varghese and Kanno 2010; Bejarano and Valverde 2013; Pérez 2014). Surprisingly, CCW theory has largely been overlooked by the ISE community.

Community cultural wealth and identity

The ISE program described in this study targeted youth with an existing interest in science. Through their own agency and desire to deepen their engagements with science, youth leveraged their existing capital as they applied for and then persisted in the program for multiple years. Their evolving identity, as someone who likes and can do science, positioned them to engage as practitioners of science and to imagine their possible selves in relation to science (Markus and Nurius 1986).

Identity development, in this study, is theorized as becoming and being agentic in that the self "represents a moment in ongoing social activities that is not stored somewhere in the depths of a human soul, but is constantly reenacted and constructed by individuals anew in the ever-shifting balances of life" (Stetsenko and Arievitch 2004, p. 494). The development of identity is mediated by sociocultural and historical influences throughout life, but also mediates changes in the sociocultural milieu in which one is situated. What we as humans do in the world contributes to not just changing ourselves, but also to changing the world. As we tell the stories of the STEM trajectories of three focal youth, we describe the identity-building moments that occurred in their lives, how they leveraged their existing capital, and how this capital integrated with the capital they gained through participation in the program to advocate for themselves and persist in their STEM trajectory. First, we describe the context of the ISE environment and the multi-year program, followed by the research questions that guided our inquiry and the methodology that guided data collection. We then discuss the patterns that emerged, and implications for ISE.

We integrate a Sewellian (1992) notion of agency/structure to describe how youth used their CCW to access and appropriate a variety of resources to build identities and resiliencies in pursuit of science in the museum and beyond. In this framework, structures are defined as schemas and resources, with the former meaning rules or "generalizable procedures applied in the enactment/reproduction of social life" (Sewell 1992, p. 8) and the latter, resources—both human and nonhuman—used to enhance or maintain power. Agency and empowerment occur when people access and appropriate resources to achieve goals and/or visions of self, in this case, careers in the sciences. As we will describe, the youth experienced different structures, mostly supportive, but some that potentially hindered their science trajectories. In the context of the ISE program, the youth brought existing structures in the form of CCW that melded with ISE structures and served to build/fortify their capital and corresponding identities, ultimately strengthening their resolve to pursue science. The youth encountered human resources, both within and in their communities and home lives, that supported their social identities as people of color and visions of self in science pursuits and later careers. As we will later elucidate, this allowed youth to persist even when they encountered structures (i.e., in postsecondary science settings) that signaled that

Table 1 The six forms of community cultural wealth

Cultural wealth	Definitions	Examples from the literature
Aspirational capital	The ability to persist or to maintain resiliency while in pursuit of one's long-term goals even when faced with significant obstacles (Yosso 2005); a form of cultural wealth characterized by the desire of a young person to exceed their parents in terms of educational achievement and social mobility (Oropeza et al. 2010)	Multiple studies have shown that parents from families experiencing socioeconomic, linguistic, and educational barriers consistently maintain high aspirations for their children and in turn, afford young people the opportunity to imagine the realm of possibilities beyond their present circumstances (Gándara 1982, 1995; Croll 2004; Oropeza et al. 2010; Basit 2012)
Linguistic capital	The intellectual and social skills accrued through multilingual communication, which allows multilingual students to interface cross-culturally and to access multiple communication networks (Yosso 2005)	Pérez (2014) found that Puerto Rican youth use linguistic capital to affirm their identity through language, which allowed participants to establish diverse social networks among their peers Studies of linguistic capital have found that multilingual students attain valuable social and intellectual tools when communicating in more than one language: these include decision-making; mediation; and literacy, math, and teaching skills (Tse 1996; Orellana, Reynolds, Dorner and Meza 2003)
Familial capital	The cultural knowledge and support accrued from family and extended family networks through validation, sage advice from family members, a shared community history, familial social networks, and common values (Yosso 2005; Murjani 2014)	Examples of familial capital include role modeling by members of a kin network, the provisioning of emotional and educational support, and the sharing of coping mechanisms (Yosso 2005; Swartz 2008; Samuelson and Litzler 2016) Familial capital has been found to play a prominent role in students' persistence in academia (Nora, Barlow and Crisp 2005; Hurtado, Eagan, Cabrera, Lin, Park and Lopez 2008; Samuelson and Litzler 2016)
Social capital	The social networks and community resources accessed to create positive outcomes (Yosso 2005; Oropeza et al. 2010; Pérez 2014) including engagement with community-based activities (e.g., church and youth groups, STEM programs, and informal science education institutions) (Yosso 2005; Oropeza et al. 2010; Martin, Simmons and Yu 2013)	Social capital is associated with many positive outcomes including academic achievement, persistence, and higher education attainment (Dika and Singh 2002; Garrett, Antrop-González, and Vélez 2010) Smith, Beaulieu, and Israel (1992) found that measures of social capital reduced the probability of dropping out of school Martin et al. (2013) found a link between sustained social networks and the attraction and persistence of underrepresented students in engineering

Table 1 (continued)

Cultural wealth	Definitions	Examples from the literature
Navigational capital	The skills of individuals to successfully navigate through educational institutions with dominant culture norms (Yosso 2005); these skills include individual agency; resiliency; and the ability to overcome low expectations from others, cultural isolation, and institutional indifference (Tate and Linn 2005; Yosso 2005; Oropeza et al. 2010)	Examples include learning how to access financial aid, finding out what classes to take, and seeking opportunities to advance college/career preparedness (Yosso 2005; Luna and Martinez 2013; Samuelson and Litzler 2016). Navigational capital is linked to access to educational institutions, persistence, and academic achievement (Villalpando and Solórzano 2005; Pérez 2014; Samuelson and Litzler 2016)
Resistant capital	A form of resiliency characterized by an individual's ability to resist negative stereotypes by "proving others wrong" while in pursuit of one's long-term goals (Yosso 2005; Oropeza et al. 2010; Pérez 2014; Samuelson and Litzler 2016); involvement in community-based programs, student organizations, or STEM programs where participation challenges the status quo, counteracts historical inequalities, and dispels negative stereotypes (Huber 2009; McPherson 2014; Ceglie and Settlage 2016)	Resistant capital is often the basis for persisting in school and for succeeding academically (e.g., Luna and Prieto 2009; Burciaga and Erbstein 2013; Pérez 2014) A study of Latina/o engineering students found that students used resistant capital by engaging in role modeling and community outreach and via membership in a professional STEM organization (Revelo and Baber 2015)

they did not belong. The structures that they encountered in their homes, communities, and museum program combined to mediate their agency which, in turn, mediated their evolving identities as people of color in pursuit of science.

The museum learning program

The Lang Program (Lang) is a 7-year out-of-school-time (OST) program at the American Museum of Natural History (AMNH). It has been in operation for over 20 years, admitting a new cohort annually. The program invites youth to deeply engage with topics in the natural sciences through coursework and research experiences that leverage the museum's resources, which include hundreds of exhibits, objects, and collections, and access to scientists and science laboratories. Youth apply for Lang at age ten, when they are in the fifth grade. Museum staff visit schools and conduct outreach activities to recruit applicants who are motivated and interested in science, but who may not have opportunities or resources for OST learning experiences within their communities. Following the completion of an application and interview process, 20 children are selected annually. Parents attend an orientation event and must also commit to supporting their children to attend all 7 years of the program. Youth attend Lang throughout middle and high school, meeting on alternate Saturdays during the academic year and for three weeks during the summer for a minimum of 165 contact hours per year. The program introduces participants to AMNH research disciplines—the biological sciences, Earth and planetary sciences, and anthropological sciences—while incorporating material from the over 40 permanent and special exhibitions. Starting in the eighth grade, Lang youth join research teams and work alongside AMNH scientists and educators conducting field- or laboratory-based projects that parallel AMNH research. Embedded in these practices is a conscious effort made by program leadership to provide participants opportunities to continuously interact with scientists and educators from diverse backgrounds. To prepare youth for successful admission into college and potential careers in STEM, Lang offers college and career readiness workshops and field trips to universities. Thus, many of the intentional design principles of Lang that have been realized over time—i.e., the coursework, research experiences, behind-the-scenes tours, and repeated interactions with AMNH scientists—mirror CCW, and have allowed youth to leverage certain forms of capital (Habig et al. 2018).

Learning about and describing community cultural wealth

In this study, we illuminate the voices of three alumni and examine how they accessed and leveraged CCW from their families and communities, how their existing capital interfaced with the AMNH Lang program, and how they extended their CCW via their participation in the Lang program and beyond. Through this process, we also discovered the ways the museum supported youths' CCW and where there were opportunities to do more. Our in-depth interviews of these three alumni allowed us to address three major questions: (1) What are the forms of CCW that the youth bring to and enact in the museum program? (2) In what ways do the youth use their CCW to navigate their STEM trajectories? (3) What are existing design features of the museum program that leverage and cultivate the youths' existing CCW? Tying our evidence back to theoretical understandings, we make claims about how recognizing and acknowledging forms of CCW can help contribute to program

design and strengthen the experience of youth participants. We also discuss our missed opportunities of recognizing and leveraging CCW and use this to discuss directions for future research. We follow-up with strategies on how museum educators can leverage the CCW that youth accrue before, during, and after participation in an ISE program.

Discovering youth voices

We applied the case study method (Creswell 2013) with the goal of better understanding the role of CCW in the trajectories of three youth who participated in Lang. The participants were purposefully selected based on the following criteria: (a) member of a group historically underrepresented in STEM; (b) low socioeconomic status; (c) participated in Lang both in middle and high school (in other words, a long-term participant in the program). Each Lang participant was interviewed annually over a span of 3 years following their graduation from college. These discussions focused on each participant's background and trajectory, and on how they accrued and accessed CCW before, during, and after their experience in Lang. Each discussion occurred for approximately 2 h, and participants supplemented their responses in follow-up telephone conversations, and by submitting personal narratives and writing short answers to prompts about the forms of CCW they accessed throughout their STEM trajectories. We used open coding to identify themes associated with each of the six forms of CCW. By concentrating on the meaningful experiences of these three alumni, it was possible to generate hypotheses on how CCW can be used to improve program design and on how providers of ISE programs can draw out the cultural knowledge, skills, and abilities of its youth to strengthen participants' experiences and to support their academic and career aspirations.

Those whose voices were heard

Sage, Cody, and Lisa were all participants of the Lang program. Each of them attended the program throughout middle and high school. All three are now college graduates and are in the process of establishing their careers. In our multi-year interviews with these three alumni, each shared their unique trajectories, and more specifically, their STEM pathways, which were not always linear; they also described multiple entry and reentry points throughout their lives. In our in-depth conversations with these three alumni, each described how they accrued and accessed their aspirational, linguistic, familial, social, navigational, and resistant capital from their families, their communities, while participating in Lang, and throughout their academic and career trajectories. We share each of their stories and describe how they used different forms of capital to support their pathways toward STEM careers. To protect participants' privacy, each alumnus selected a pseudonym in place of their given name.

Sage

Sage grew up in East Harlem, New York, a neighborhood known as "El Barrio" in recognition of its Puerto Rican diaspora (Whalen and Vázquez-Hernández 2008). Sage is a second-generation Puerto-Rican American. Her parents are bilingual speaking both Spanish and English. In Sage's neighborhood, the local school district is among the five lowest

performing school districts in New York City (Reyes 2012). Despite the high concentration of low-performing schools in her community, after taking a gifted and talented examination, Sage gained admission to and attended the highest performing elementary/middle school in her neighborhood. For many years, this school was the only gifted and talented school in New York City that served nearly one hundred percent African-American and Latino students; to date, gifted and talented programs in New York City continue to predominately serve Asian and Caucasian students (Lu and Weinberg 2016). After graduating from her middle school, Sage continued her public school education in East Harlem and attended a high school that specialized in science and mathematics; she was also an advanced placement (AP) student. While growing up and throughout Sage's educational trajectory, she credits her parents for encouraging her interest and persistence in STEM. Sage is presently a high school mathematics teacher in Philadelphia, Pennsylvania.

Cody

Cody is an African-American male born and raised in Brooklyn, New York. He attended his neighborhood public school for both elementary and middle school. From as far back as Cody remembers, he was always interested in science: In 8th grade, he applied to and was accepted into a very selective public high school in New York City where he joined a program that focuses on preparing students for careers in the medical sciences. Following high school, Cody attended a local private university where he earned a bachelor's degree in chemistry. He is presently working for a city agency where he conducts environmental safety testing on air and water samples. When he is not at work, he spends most of his spare time teaching himself coding as he aspires to be a web developer.

Lisa

Lisa was born and raised in Brooklyn, New York. She is a first-generation Vietnamese-American, and the youngest of five siblings (four girls and one boy). She is the only one of her brothers and sisters born in the United States; her parents and siblings emigrated from Vietnam the year she was born. She grew up in a low-income, predominantly Afro-Caribbean community where she attended her locally zoned elementary and middle school. During elementary school, Lisa developed an early interest in science, which was influenced by her older sister's shared interest. Following middle school, Lisa attended a high school located in lower Manhattan and upon high school graduation she attended a small liberal arts college in upstate New York where she majored in biology. After earning her undergraduate degree, Lisa was employed as a Clinical Trials Data Manager at a medical center where she was responsible for coordinating leukemia trials.

Emerging themes

We draw from CCW theory because it allowed us to recognize and acknowledge the skills, abilities, and networks that youth bring to the table based on their unique trajectories (Yosso 2005). The alumni we interviewed exhibited all six forms of cultural wealth; these forms of wealth were leveraged throughout their STEM trajectories, that is, before, during, and after participation in the AMNH Lang program. From our interview data, we identified four salient themes, which we elaborate on below, in the context of CCW theory. The

first theme we unpack is how participation in the program *expanded the realm of possibilities* for what STEM is, what doing STEM could be, and the options for careers in the STEM disciplines. The next theme that surfaced was *creating and sustaining STEM social networks*. Youth brought strong networks with them as they entered the experience, developed new relationships, and then sustained certain relationships as they persisted with their STEM trajectory. The third theme is how youth demonstrated *resiliency while facing significant obstacles* along their pathway. Finally, the fourth theme is the *continuum of STEM experiences* of the focal youth during multiple entry and/or re-entry points during their nonlinear STEM trajectories.

Theme 1: expanding the realm of possibilities

The ability of individuals to imagine a realm of possibilities beyond their present circumstances is an important component of CCW theory (Gándara 1982, 1995; Croll 2004; Oropeza et al. 2010; Basit 2012). We found that each of the focal participants leveraged different forms of capital during the process of forging a STEM identity; some forms of cultural wealth were leveraged throughout participants' STEM trajectories while other forms emerged later, either during their participation in Lang or as college students. During the formative stages of their STEM identity development, focal participants largely leveraged their aspirational, familial, and navigational capital. While participating in Lang, our data suggest that students had multiple opportunities to practice science in different ways (Habig et al. 2018), affording opportunities to augment their aspirational and navigational capital and to leverage their social capital via interactions with scientists and educators. Following their museum experiences, the focal participants went on to college where their STEM identities were further transformed as they partook in additional authentic STEM experiences. During this time, participants described how they became even more adept at leveraging their CCW while in pursuit of their long-term goals. Indeed, our data suggest that all forms of CCW were strengthened as participants shaped their individual STEM identities with each iterative STEM experience. Sage, Cody, and Lisa, our three focal participants, leveraged different forms of CCW throughout their STEM trajectories while expanding their realm of possibilities.

Sage leverages different forms of CCW to expand her realm of possibilities

An important aspect of aspirational and familial capital is the idea that parents hold "high aspirations for their children's future" (Yosso 2005, p. 78). Sage described her parents' desire for her to achieve her educational and professional goals as a strong motivational force for persisting in school and for continuing her participation in the Lang program throughout middle school and high school. She reflected:

> I don't know if it's like a Latino immigrant mentality, the ideal that I have going on for myself. When you grow up with parents like that, that type of mentality is put into your head…you have to do better than us, we're doing all this to help you. You have to help yourself. You're going to do this for your children. They never let me quit.

Through her mother's encouragement, Sage leveraged her aspirational and familial capital as she realized that participation in Lang might expand her realm of possibilities.

After Sage interviewed for and was accepted into Lang, her mother strongly encouraged her to join the program: "[My mother said] don't waste this opportunity…You don't realize how special you are". Sage joined Lang and recalled that it was challenging to balance her commitments—conducting rigorous research at Lang while maintaining her responsibilities as a middle school student. She attributed her mother's influence in terms of her persistence: "[My mother said] you have to do this…there are so many other kids who would kill to have this network, to have this opportunity literally thrown at them."

Like her parents had hoped, as Sage matured, she too began to imagine the realm of possibilities beyond her present circumstances: "I think I started realizing that Lang was the game-changer when I got to high school because it was the thing that made me different from everybody else…I didn't grow up with much, but I got to have this opportunity that leveled the playing field for me." Indeed, Sage's participation in Lang and her recognition that participation in this program might be a "game-changer" was evidence that she was also leveraging resistant capital as she forged her STEM identity. One form of resistant capital includes involvement in community-based programs, student organizations, or ISE programs where participation serves to challenge the status quo, counteract historical inequalities, and to dispel negative stereotypes (Huber 2009; McPherson 2014; Ceglie and Settlage 2016). Sage was part of a community of scholars with similar backgrounds as her own and was interacting with a diverse group of scientists and educators. "In Lang" she said, "I wanted to be like these people. These are great people. We can cultivate something together…It doesn't have to be the way it has always been or the way we perceive the world to be." As she reflected on her tenure at AMNH, she explained why she thought Lang was particularly important for her and her peers:

> Other kids could have access to other programs because of their social status. Others with higher status may not have been as impacted by the program because of their background. Like other kids in Lang, I came from a place of adversity…I know what it's like to have fear walking home. I know what it's like to hear gunshots walking home.

To Sage, her experiences at Lang helped to shape her identity: "They've given me experiences that has shaped my life to the point where it allowed me to figure out what is it that I'm good at, what is it that I like…and who I am as a person in the sphere of academia." Sage said that she thought that her story was relevant to other students in Lang and to other young people who came from a place of adversity. "We share a common ground", she said.

In addition to resistant capital, Sage also leveraged her linguistic capital to expand her realm of possibilities. Sage credits her cross-cultural experiences at AMNH as the first time that she realized that a STEM career was a possibility:

> In middle school, when I came here [Lang] and saw all the people working here and I finally saw people that looked like me…I see Hispanic people, Southeast Asian people, black people, Native American people…I see people of every color doing the things that I want to do.

Prior to this experience, she stated that she previously associated STEM careers with white males. One educator, a Hispanic female with a Doctorate in Education, afforded Sage the opportunity to leverage her linguistic capital, as well as her aspirational, navigational, and social capital, by offering Sage education and career advice. Sage recognized her as a source of personal motivation: "[She]…was so inspiring. Wow, I could be you. I look up to you. You look like me. You speak like me. We share a language…and it's possible."

Thus, Sage's experiences at AMNH afforded her opportunities to cultivate social and academic support from scientists and educators that shared a common language and a common heritage.

Finally, Sage expanded her realm of possibilities by leveraging her aspirational and social capital via engagement in multiple experiences as a STEM practitioner. During her sixth and seventh grade years in Lang, she remembers participating in an inquiry-based research project called *Young Naturalists*. As part of this national science research competition, Sage needed to develop a research question, formulate hypotheses, collect, organize, and analyze data, and communicate her findings. Sage selected a project based on a behavior she noticed by looking outside the window of her apartment building—the flight patterns of rock doves (*Columba livia*), commonly known as pigeons. For the next 2 years, she conducted field observations collecting and analyzing data on pigeon behavior. She recalls that she made it to the final round of the national competition receiving an honorable mention: "You have this little girl from Harlem who is like competing with these people who have more than me. It was something really exciting. It validated me." In high school, Sage leveraged another opportunity to become a practitioner of STEM, an experience that she says sparked her interest in mathematics research. In her calculus class, she was assigned an open-ended, inquiry-based project where she had to use calculus to explore a research question. She ended up asking whether it was beneficial to walk or run in the rain, and analyzed the shape and trajectory of raindrops and different types of rain. "It ended up being inconclusive, but it was a really good project. It was fun to do…that's how I really got interested in math." As an 11th and 12th grade Lang student, Sage conducted authentic ornithological research alongside scientists working at Great Gull Island, a long-term research site facilitated by AMNH. Thus, by the time she arrived at her college, the social and academic capital that she had leveraged from her repeated authentic research experiences and her repeated collaborations with STEM educators and scientists, allowed for a smooth transition into a research track: Her mathematics professor recognized her talents, and during her freshman year, she was awarded a mathematics research fellowship.

Cody leverages different forms of CCW to expand his realm of possibilities

Like Sage, Cody leveraged different forms of CCW to expand his realm of possibilities. As a middle school student, Cody augmented his social capital by gaining mastery of his school subjects, especially science, which earned the respect of his peers and teachers. Consequently, Cody's middle school teacher recognized his potential and recommended that he apply for the Lang program. To gain admittance into Lang, Cody leveraged two additional forms of capital: navigational and familial capital. In terms of navigational capital, Cody took the time to research the requirements of the Lang program, which included an interview in which he was asked to show off his science interests by creating a shoebox exhibit. Cody recalls spending hours preparing for his presentation: "I did mine on neurons", he said. In preparation for the interview, Cody recalls constructing clay models of different types of neurons. In terms of familial capital, his mother insisted that he dressed up for his interview: "I had to be pushed into wearing a suit for the interview. [My mom said] you're going to stand out if you wear a suit." Following the interview process, Cody gained admittance into this highly selective program.

During his first year in the program, Cody recalled participating in an inquiry-based botany project where he developed an original research question, formulated hypotheses, and collected data in Central Park. After Cody analyzed his data, he wrote a research paper

and like Sage, entered it into the *Young Naturalists* competition. As a result of his efforts, Cody was recognized as a semi-finalist. However, in subsequent years, although he continued to participate in authentic research projects and to submit his work to the competition, he never received the same recognition again. Instead of giving up, Cody leveraged his aspirational capital and used his initial success as a source of motivation: "When I got it, that kind of recognition, [it's] like you kind of want to keep going, like you never want to take stuff backwards." During Cody's last 2 years in Lang (junior and senior years of high school), rather than participating in an individual research project, he opted to join an advanced research team. For this project, Cody and his Lang peers conducted fieldwork at different locations throughout the New York metropolitan area where they collected Atlantic silverside fish. Following their fieldwork, he and his colleagues conducted laboratory work to test genetic diversity by extracting and sequencing DNA, and then used bioinformatics to analyze their data. The participants of this project, including Cody, communicated their research at the World Science Festival and entered their poster into a DNA barcoding competition. Cody described the experience as follows:

> I remember…the project…and I felt like that was pretty big because I felt like that was really…the most technical and advanced thing that we had really done in terms of the depth that we were going into because it was like…write your research proposal and we would have these weekly meetings where we would come in and share articles and read articles and [our mentor] would go over them with us and we were using Geneious Pro [and other] computer programs…We were doing DNA sequencing and actually doing these experiments. That was probably the most intensive thing that I'd done and I remember like actually really enjoying it and there was a time when we were even like volunteering to come in after school on our own…We all kind of like took the extra initiative but it wasn't actually a chore. We really enjoyed doing it.

Cody credits these research experiences at Lang for transforming his STEM aspirations: "So I think Lang really opened up possibilities. It kind of gave me more exposure to more career opportunities that might be out there in the sciences because I thought when I was younger, it was doctor and that was it because that's what everybody says."

Lisa leverages different forms of CCW to expand her realm of possibilities

Like Sage and Cody, Lisa's familial capital played an important role in her academic and career trajectory. Lisa's familial history, particularly her mother's trajectory, played a prominent role in forging her identity. Lisa's mother was born in the midst of the Vietnam War, and as an Amerasian, she was greatly stigmatized by native Vietnamese, often referred to as "children of the enemy" or "dust". Months after the Vietnam War, Lisa's grandmother passed away and Lisa's mother dropped out of high school to become the caregiver of her 3-year old sister and 7-year old brother. Continued prejudice against mixed-race children led to tens of thousands of Amerasians being granted approval to immigrate to the USA. In 1989, the year her family arrived in Brooklyn in pursuit of a better life, Lisa was born. Because Lisa's parents were divorced, Lisa's mother largely raised the family as a single parent. Lisa recalls that her mother worked multiple jobs including factory work, nail technician, collecting and recycling bottles and cans, and even selling Vietnamese desserts. Lisa's mother, with the help of her older siblings, eventually saved enough money to open

her own nail salon. Lisa said that watching her mother manage and operate her own business was her fondest memory of her:

> Just seeing her manage her business [was] my proudest memory…We had an office in the back of the salon, and I remember her just like writing inventories or counting money and sorting things out and she would have me help out. I think I gained some sense of leadership from that experience observing how [my mother] managed the salon. I love to organize, coordinate, and manage events, and I can see how my attention to details, customer satisfaction, and hospitality stem from my mother's example as an entrepreneur.

Lisa' older sibling also played a prominent role in her STEM trajectory. When Lisa was in middle school, she was selected to participate in the Lang Program at AMNH. However, unlike Sage and Cody, it wasn't her parents or teachers who encouraged her to apply; instead, she leveraged her familial capital from one of her older siblings: "I became aware of the Lang program through my sister…She was a member of [Lang]…She was my older sister and I was always admiring what she was doing in Lang…I looked up to her, and she would just come home with a lot of stories of the field trips she went on and projects she was doing so it was only natural for me to follow along and interview for Lang." Lisa recalls feeling a sense of autonomy during her multi-year experience at AMNH: "…Going to Lang and being exposed to STEM really encouraged me…I was encouraged to ask questions, to take initiative, and create my own projects."

When Lisa was in middle school, she participated in several independent research projects just like Sage and Cody. As a result of these efforts, she won a national science competition and was featured in local newspapers. Lisa voiced that these experiences contrasted with her home experience where "the adult makes the choice for the kids a lot". She stated: "I get the sense that by being overprotective, adults can inadvertently hinder a kid's creativity, repressing their voices and thoughts." In high school, Lisa expanded her participation at AMNH; she joined a Lang research team in which she and her peers (including Sage) conducted ornithological research on Great Gull Island. She also joined YouthCaN, a youth-run organization sponsored by AMNH designed for youth concerned about the environment. These experiences afforded Lisa multiple opportunities to leverage and augment her aspirational and social capital via participation in authentic research alongside AMNH scientists and educators and by interacting with her peers planning environmental stewardship projects. Lisa indicated that these experiences helped to solidify her career aspirations: "If I didn't go to Lang and I had not met [AMNH educators and scientists], I would have just been limited to my immediate teachers in school and I don't think I would have sought out competitive careers that I could be passionate about."

Theme 2: maintaining resiliency while facing significant obstacles

Returning to the notion of agency and structure, the three focal participants encountered structures that served as obstacles in their pursuit of science. However, their existing CCW and the ways that it evolved in the Lang program allowed them to have agency and resilience despite the challenges that they faced. Below, we describe how these individuals leveraged their CCW when faced with personal obstacles, how they addressed issues connected to their racial identities, and how they persisted through difficult college

coursework—all of which are well-documented reasons for college dropout among marginalized youth (Nora et al. 2005; Palmer, Davis, Moore and Hilton 2010; Cromley, Perez, and Kaplan 2016).

Cody leverages CCW to overcome obstacles

Familial capital is manifested by the sharing of common values among family members (Murjani 2014). For all three focal youth, the nature of their relationship with their parents was critical. While growing up, it was evident that Cody's mother placed enormous value on education. Although she worked full time, she managed to complete her degree while simultaneously raising her son. Cody recalled that his mother always made education a "point of emphasis" and made sure that there was enough money available for him to purchase books so that he could singularly focus on his academic goals. "My mother", Cody recalled, "always really tried to push me to be the best and go for the best and not really settle so that was actually, you know, I appreciate her for that and that's really big." Cody recounted a time when he slipped on ice and hurt his arm: "She [my mother] was like you're still going to school…no days off." Because of the familial capital gained from his mother, Cody also places great value on education. As a college student, Cody followed his mother's example pushing himself to persevere: "I remember just like constantly [going to the library]. I would take the whole package sometimes [of paper from the printer] and [practice problems] …till 2 am or 3 am in the morning and wake up for an 8 am lecture." His motivation to learn is evident to the present day as he teaches himself computer language: "So, she really instilled that characteristic and value in me to just, you know, power through and be consistent with the things that you do." As an aspiring coder, he still considers his mother's example as a motivational force:

> So now that I am just trying to juggle coding and going to work, like sometimes I'm just so tired, I think about [my mother]…if she can have a kid and a job and still go to college whereas she's probably studying four different subjects at a time and I'm just studying one, then it's like, I should be able to find a way to make this work. And so just seeing that, having like a point of reference, it kind of taught me about perseverance, working hard.

Thus, for Cody, his mother was a role model, and her example was a motivational force contributing to his aspirational capital.

Sage leverages CCW to overcome obstacles

Sage credits both her parents for serving as examples and instilling within her a sense of resilience throughout her schooling. Her father instilled a work ethic and served as an example of how to persevere when things got tough:

> My dad always showed me a really strong work ethic. You got to get up every day. You got to work through the pain. You have to make sure you're looking correct, acting correct, talking correct…that's something that I always took away from him.

Sage's mother inspired her to persist throughout her education trajectory. Sage said that while her mother may not have been able to help her with her science or math homework, she remembers her mother providing support by consistently being present. When

Sage was in Lang, her mother called on a daily basis to make sure that she arrived safely at AMNH and insisted that she put one of the educators on the phone. "It was an accountability thing", said Sage. "My mom made it very clear, especially when I was in high school; she was like this is what is going to get you into college." Throughout middle and high school, her mother would also regularly communicate with her teachers. Because of these familial influences, Sage said that as she progressed through high school, she started to realize that college was "becoming more of a reality".

While in college, Sage planned to pursue a Masters and a Ph.D. in mathematics, and to pursue a career in academia. However, her plans were thwarted during her junior year: "I got booted from school for getting into…just like down a bad path." After Sage was separated from college, she moved back home with her mother: "Seeing her being concerned…and she's sickly…She didn't have to be worrying about that…seeing that just shows me like—she wants me to be better…" Sage's mother continued to encourage Sage, first when she found a job doing freelance research and again as Sage decided to reapply to the same college:

> She has every positive interest of mine in her heart…I feel like it's really hard for a lot of people to like stay positive. Even when everything seems to be falling apart in her life…and her candle of positivity is blown out, she keeps that candle of positivity on for me no matter what.

Thus, even though Sage faced a number of setbacks during her academic trajectory, her familial capital, especially the educational and emotional support she received from her parents, helped her to persist especially during challenging periods.

Although Sage's family was supportive, her situation was tough. Her mother first suffered from cancer and then later a stroke. Her grandmother, who was a major point of support for her, died while Sage was in high school, and her father continually struggled with addiction. Sage recalled, "I was in a very serious emotional place…I was missing a lot of school when I was in middle school and high school." In addition to these challenges, she was also concerned that some of the negative influences in her neighborhood might be an obstacle to achieving her goals: "The neighborhood I grew up in…I'm surrounded by gangs, drugs, medical issues, violence etcetera so it's like really hard to remove yourself from that…that's an obstacle in and of itself." For her, Lang became an alternative setting where she felt like she belonged:

> I knew that I wanted to get out of the hood…I knew that I had more intelligence to make the right decisions…to not put myself in that situation that my peers were in…I knew that from like my dad's experience with drugs…my mom's experience with health…I knew that I had to keep on the right track. I knew that I had to take care of my health so the thing about it is like even though these things are obstacles… I had the right education. I had the right people in my life to make sure that I wasn't doing those things.

Sage says that the Lang program gave her a place to focus her energy in a positive way and on something that was authentic and contributing to science:

> When all my friends were out partying, like having a good time, hanging around, like going to skate parks or whatever. I was here like doing what I had to do. We were entering our projects [in a competition], we were submitting our papers, and that was a point of pride for us.

This aligns with Roth and Lee's (2007) notions of engaging youth in authentic meaningful activity and Stetsenko and Arievitch's (2004) ideas of life being a meaningful project. For Sage, the project in Lang became much more than a project; it became a doorway to escape her family circumstances. Sage said that even though the workload at Lang was sometimes burdensome, she felt that being immersed in a project with her museum peers helped her to overcome many of her problems:

> …Well, when things were really bad at home, well at least I could come here and [when] I'm not feeling too good about the things that are going on at school, I would come here and I knew that there was a space here for me…It was peace."

Sage expressed that her resiliency paid off: "I focused my energy on the good rather than the bad. I really feel like that was one of the things that helped me to be OK, to be out on my own and to leave here [attend college]." She graduated from high school as an honor student.

Sage knew that if she wanted to achieve her long-term goal of going away to college, she was going to not only need to excel academically but find a way to pay for college. Upon completion of the Lang program, she received a modest stipend, which helped her with some of her college expenses. When Sage was in high school, she found out about a 2-year internship at a world-renowned medical school and hospital located in the East Harlem community. By participating in this medical internship program, Sage earned more money to pay for college. When it was time to apply for colleges, Sage met with her high school guidance counselor, and found out that because of her socioeconomic status, she qualified for college application fee waivers: "I applied to 20 colleges because I had a ton of fee waivers." Remarkably, Sage was accepted into nearly every college that she applied for, and because her goal was to go away to college, she narrowed her choices to two out-of-state colleges. However, there was a problem. Even with the stipends she received from Lang and the medical internship, and the scholarship money offered by these two colleges, she said there was no way that she could afford to go away to college. In an impressive display of navigational capital, as a 17-year-old high school senior, she called both schools she was interested in, explained her situation, and requested additional scholarship support. One of the two schools, an all-women's college, offered her additional support, and as a result, she left home to fulfill her dream of going away to college.

Lisa leverages CCW to overcome obstacles

Growing up, Lisa encountered obstacles both at home and in school that made it challenging for her to persist in a STEM trajectory. Lisa said that several factors—her parent's divorce, her home environment, her personal struggle to simultaneously maintain and resist her Vietnamese identity, and her difficulties assimilating into a predominately all-white college in the suburbs—affected her well-being; she found herself struggling with anxiety and depression. According to Shrake and Rhee (2004), Lisa's struggles are not uncommon. In their research on immigrant families, they found that Asian American adolescents often face psychosocial challenges borne out from competing tensions between cultural/familial expectations and societal pressures. Despite these challenges, Lisa remained resilient:

> Although my environment wasn't by any means conducive to studying or learning, the pressure and expectation to go to college, to do better than my parents, was always present. There was never any question in my own mind that I was going to make it to college – but not because I associated higher education with a promise [of]

> a better future. No, it was because I saw going away to college as a way to be physically free from my family. It was an excuse to move away from my family, to gain autonomy and to remove the shackles of Vietnamese culture that had caused so much anxiety…

Yet, college was also a struggle. Lisa found it difficult to maintain her grade point average and to adjust to her new environment: "I was admitted through a special program, which provides academic support, tutoring for example, and financial assistance to disadvantaged students, which really appealed to me at the time." However, she recalled, "just getting into a good institution didn't automatically ensure a smooth and successful academic and social experience, as I was not prepared for the sociocultural shock." Although her undergraduate experience was at times daunting, Lisa persisted despite, as she described, "falling into a deep, dark hole" and feeling "unfulfilled, and uncertain". However, Lisa managed to use her navigational and social capital to persist; during her senior year of college, Lisa collaborated with one of her professors, and completed a senior thesis on kidneys and diabetes, which involved working in a laboratory studying diabetic mice. Moreover, following graduation, she leveraged her research experience to get hired by a major medical center as a Clinical Trials Data Manager.

Leveraging resistant capital to maintain resiliency

Cody's racial and physical attributes could easily have become barriers for him because of racial stereotyping encountered by African–American males (Ellis, Rowley, Nellum and Smith 2018). Instead, Cody realized he could use his physical features to stand out and be noticed and remembered for positive experiences. For him, it was a source of pride to exceed others' expectations and to excel academically. While Cody recognized that being a tall African-American male at his university could potentially be a disadvantage, he said that he used his identity as an advantage:

> I remember I would go to school; it was like, I wouldn't even introduce myself and the teacher already knew who I was. So, I think…I think like I made it work…I think like because I was so driven, it ended up working in my favor because I made it. I already stood out, and I stood out for a good reason, but if it was like I was failing or if I didn't care, then it would be…basically I feel like everything you do, it like has double the, like double the meaning right so if you do something bad, it's like two times as bad. If you do something good, it's like two times as good. I definitely think I made it work for me in the sense like OK…if I didn't go to class, they'd notice [Cody] is not here. When I'm in class, OK [Cody] is here, hey [Cody], how you doing? I was really able to get that personal connection whereas somebody else might have had to try a little bit harder because if you're in a class full of one hundred Asians, it's like Asian students need to talk to the professor, maybe like on a daily basis before you really start to stick like as who you are. Whereas like me, I think I was one of like three or four black kids in my major. So, it's like I talk to you once or twice…you kind of remember who I am already.

Lisa's resistant capital took form in the resiliency she exhibited while resisting negative stereotypes of Asian Americans. While growing up and throughout her adult life, Lisa experienced two of the most common forms of racial stereotypes encountered by Asian

Americans, racializations as the "model minority" and as "forever foreigners" (Tuan 1998; Ancheta 2006; Ng, Lee and Pak 2007). Lisa reflected:

> Growing up, I lived and attended public schools in a predominantly black neighborhood, with very few Asians. At school, I was often stereotyped as the 'model minority'. Teachers would reprimand my friends instead of me when they heard us chit-chatting in class because I was always stereotyped as shy, quiet, and hardworking, and thus automatically obedient.

Lisa was also the recipient of insulting and disparaging remarks while walking through her neighborhood. "I remember always making sure to walk home with at least one other friend", she recalled, "so that when the disparagements and insults came, I could pretend that I couldn't hear them. I have had 'ching-chong' and 'chicken wings, pork fried rice' and 'China' shouted at me." Just like Sage, Lisa said that she considered Lang her escape from problems that she sometimes encountered in her neighborhood.

When Lisa attended college, she had high expectations expecting to, in her own words, "have full autonomy over my life" and "a smooth and supportive educational journey". However, Lisa faced a multitude of challenges:

> My journey was far from smooth. It was a battle…I was a minority, and I would be forced to face the reality of being racially and economically disadvantaged. To give you an idea of what it was like, approximately 2000 people attended my college, a predominantly White institution…Of those, only seven percent identify as Asians. As a minority on campus, there were obvious sociocultural difficulties [and] challenges. Personally, I felt torn as I tried to assimilate into the dominant culture whose values differ greatly from that of my Vietnamese traditions.

While she was ostracized during her adolescence for being Asian in a predominantly black neighborhood, as a college student, she now felt out of place for being one of the only Asians in a predominantly white college. Although Lisa struggled, sometimes experiencing anxiety and depression, throughout this daunting experience she continued to access her resistant capital by countering negative stereotypes via collaborations with professors, taking on leadership roles, including the coordination of fundraising events, and proving others wrong by continuing to concentrate on her long-term goals. Throughout this trajectory, Lisa repeatedly accessed her CCW using different forms of capital to navigate and traverse the academic landscape.

Leveraging CCW to maintain resiliency during advanced college courses

Encountering challenging courses in college is a common obstacle. Aside from gatekeeper courses, advanced STEM courses can feel daunting and often serve as the reason why STEM majors dropout (Cromley et al. 2016). As a chemistry major, Cody was required to take quantum mechanics. He recalls that the class was exceedingly difficult and math intensive: "It was a class for my major so if I didn't pass it, I wouldn't graduate… I remember there was a time when I was like wow, I might not graduate." In the face of this challenge, Cody maintained his resiliency by thinking about other students who came before him who had struggled with this class, yet still passed: "So I was just like either I have to put in more hours or I have to change something up. It's not impossible and when you realize it's not impossible and…you can do it too." He drew on his aspirational and resistant capital to generate the fortitude to deal with this challenge. Accordingly, Cody said that he was able

to pass his quantum mechanics class because his relationship with STEM helped him to "think differently from most people":

> It's also like a source of inspiration… like I've hit a wall before and made it through so…whatever this is that I'm doing now…it's only a matter of time as long as I keep at it. I'll break through eventually.

Cody attributes his repeated experiences with STEM as helping him to persist even when faced with significant obstacles. Programs at informal science learning institutions are designed with the intention to support youth in developing skills of problem solving, and that means developing an awareness that when a problem feels too hard, the first step is to break it down into steps and tackle each smaller problem. Cody realized that his repeated experiences of problem solving became part of his practice with STEM or as he states, "his relationship with STEM". He expressed that this asset made him different from peers who might not be able to persist. In Cody's trajectory, he continually encountered significant adults who challenged him and contributed to his evolving identity as a problem solver. For example, during Cody's freshman year, he remembers an interaction with the Principal Investigator (PI) of the laboratory in which he was conducting research that changed his perspective on how to deal with challenges:

> I had like a bunch of questions and I went to ask the PI thinking I was going to come out getting answers and he was like, well what do you think we have you here for? You know when he said that it was kind of like…it kind of made me realize there are things out there that are not answered and it is really up to you to go out there to do research and kind of interpret things on your own.

Throughout Lang and then in college, Cody exhibited a nature to persist. At Lang, he was provided with tools and exposed to a variety of research experiences; these experiences extended into his college years where he gained new strategies that taught him to persist. Throughout this period, Cody exhibited an ability to leverage these experiences as a way to move ahead even when faced with significant obstacles.

Sage also described how she encountered difficulties with a harmonics analysis class in college, but states that Lang helped her develop the skills to figure out who the support systems are and the resources that can be tapped to overcome the obstacle.

> I just wasn't getting it…and that was something that I learned from the museum… if you don't understand something, then someone is going to be there to help you so like I started utilizing my resources. I started being comfortable going to my professors…That's also something Lang taught me to like pinpointing what is the problem. It's not like, oh I can't do it. It's, I can do it. I'm just having a hard time with this. That's something that I thought personally helped me face adversity by understanding how my mind works, understanding how I receive help, and how is it that I perceive help…like if you're helping me, how am I taking it in…also how to ask for it, and how to specify how I'm asking for it.

Theme 3: creating and sustaining STEM social networks

Conceptualizations of social capital theory have independently emerged from the seminal works of Bourdieu (1986), Coleman (1988), and Lin (2002). These include emotional, academic, and career support (e.g., preparation of college applications;

scholarship help; advisement; counseling) and engagement in community-based activities (e.g., access to and participation in church and youth groups, STEM programs, and ISE institutions) (Yosso 2005; Oropeza et al. 2010; Martin et al. 2013). The criticality of creating and sustaining social networks is documented for youth programs (Habig et al. 2018). However, what youth bring to these social networks and what kinds of CCW they draw on to develop their STEM social networks has not been explored fully. For the three participants in this study, CCW manifested in their existing self-efficacies, interests in science, connections to the people in their lives who are often not talked about, and connections to each other; each played important roles in setting them up for leveraging opportunities during their museum tenures to deepen their STEM social networks. Drawing on several forms of capital, we share the social networks they had in place as they entered Lang, the ones they developed in the program, and then how these networks became salient in their college and career pathways.

Leveraging different forms of CCW to create and sustain social networks

In Lang, the youth participated in authentic science research with the opportunity to do new and different projects every year. They developed their own research questions, collected and analyzed original data, and communicated their findings to the public. By working with a team of like-minded peers as well as AMNH educators and scientists, the three focal participants described how participation in Lang afforded them multiple opportunities to create and sustain social networks. Cody, for example, stated, "you just kind of formed a little bit of a community that doesn't really go away. It's great to know that you have that community there…These are people you can depend on." Sage described this community of Lang peers as a network: "My actual team was a big network of support for me, huge network of support for me…these people are still some of my best friends." She added that her museum network extended beyond the peers in her science team to museum adults interested in fostering her interest in STEM: "I felt like the network here of the educators and scientists were so warm and welcoming and very, very willing to work with students…You know like they want to help us. They want to influence these kids." Lisa also described her relationship with other museum participants, and recalled leveraging her friendship with one of her Lang peers to take on leadership roles. Lisa reflected, "She and I were so comfortable with each other and we were so accepting of our weirdness that when we came to the museum, we transferred that energy and acceptance onto our other teammates." Lisa and her friend would schedule informal nature expeditions to local parks and encourage the other Lang participants to join them:

> We would go on our own explorations. I remember we were always able to convince a group of students to come with us… I remember [other students], they would come with us at lunchtime or even after Lang and go to the park and wander around because it's inexpensive and it was fun.

Through the years, Lisa and her "team members" formed strong social bonds and developed shared science identities as they negotiated their capital and learned their individual/collective space within the museum and the larger scientific enterprise. "We were good influences…We just encouraged exploration and like we were always really into the

activities. I think that helped pull and motivate other students too." Lisa believes that the social capital she accrued during her interactions with her Lang peers influenced her life:

> It definitely shaped who I am today. The middle school I went to didn't have a lot of programs. I guess I could have veered in different paths very easily, and I think…the museum was sort of my outlet to be as nerdy as possible and be around a…group of students who had the same interests…It enabled me to maintain my interest in science. So, I think it was essential in shaping the path I took to college…

Cody's existing social networks expanded beyond his home environment extending to his Brooklyn neighborhood and local school community. He joined a community youth basketball program. He described his coach as being critical and having high expectations. "What he [my basketball coach] was really trying to do was prepare us for the real world. So, I feel like now that I'm older, I can [take criticism]. I can overlook how it is said…You kind of take that and learn from that, and that's pretty cool." Cody brought this navigational capital in the form of an awareness of how to negotiate interactions with the world to his school, and to his Lang and college experiences. As a college student, to accomplish his objective of finding a research lab, Cody perused the college Web site and attempted to review each professor's work and to read their research articles. Next, he sent emails summarizing the articles and expressing his interest in joining their labs. However, Cody hit a wall: "They just weren't getting back to me. I remember I was just like…I don't even understand half of these articles. I can't do this anymore." However, he did not give up. Instead, he contacted his mentor from the Lang program and together they worked on crafting a cover letter and curriculum vitae. Cody described them as "going back and forth" until he drafted a polished product. After emailing a number of professors, shortly thereafter, Cody was invited to join a research lab. Cody stated that the PI of the laboratory selected him because of his experience at the museum: "So, he [the PI] told me that because I see here that you have the experience and you stuck with it [Lang] for 7 years, I trust that when things get sort of slow, that you won't just leave." Indeed, Cody worked in this laboratory conducting research on a protein that functions in a cancer repair pathway throughout his tenure at the college. As an upperclassman, Cody also joined a bioinformatics laboratory where he was able to carry out research connected to his "newly found love for computer science". Thus, the intersection of Cody's aspirational and STEM social capital together with the activation of his navigational capital were collectively important as he navigated through a large research institution in an effort to achieve his educational goals.

Similar to Cody, Lisa discovered museum mentors that were critical for her trajectory. One museum educator was instrumental in providing academic and career advice, reviewing her curriculum vitae, writing letters of recommendation, and for providing additional networking opportunities. Over a decade removed from Lang, Lisa said, "I still go to [him] for advice, and to look over applications or ask for [his] advice." Another mentor, a retired scientist, was a source of inspiration for Lisa. She reflected, "I really admired him. He was so passionate with his work that it didn't seem like 'work' at all…that sort of dedication to excel in something you love has influenced me to this day and makes me really passionate about what I do." One particular interaction with this scientist when Lisa was in middle school is etched in her memory:

> I once spotted a dead brown bat on the road in Prospect Park, Brooklyn. Because I was so used to seeing educators/scientists at the museum collect and preserve animals/plants, I thought it was only natural that I do the same with this bat. In

> an effort to "preserve" my specimen, I swept the bat up in an empty bag of chips I found on the side of the road, wrapped it up in a few plastic bags at home, and left it in my family's freezer for a few days. Once I was available to visit the museum, I went and sat with a retired naturalist, who was in his eighties. It took us over 6 hours to clean and stuff this bat, which is kept on display in the Discovery Room. I wouldn't consider myself an amateur taxidermist by any means, but I don't mind spending hours doing something for the sake of science, and I don't find the thought of dead animals, live insects, as repulsing as most people do.

STEM capital

In recent years, a subset of social capital—*science capital*—has been identified as an important source of self-efficacy (Archer, Dewitt and Willis 2014; Archer, Dawson, DeWitt, Seakins and Wong 2015). Students with high science capital have been found to be more interested in studying science at a university, more confident in their science abilities, and more secure in their identity as a "science person" than students with low science capital. An important aspect of science capital is engagement in science-related behaviors and practices that promote sustained interest in science (Archer, DeWitt, Osborne, Dillon, Willis and Wong 2012). Lisa picked up a dead bat, and knew exactly who to bring it to for preservation. Sage recognized the resources she had: "… having access to the labs, having access to the materials, the specimens…being able to see those things; other students are never going to be able to see those things. I saw a frozen penguin. I've seen the coelacanth [ancient fish species], held those scales." Sage felt that this science capital in the form of exposure to objects and specimens would be something that put her ahead of the game as her peers in college wouldn't have such experiences. As Sage reflected on her STEM trajectory, she recognized that the social networks and community resources that she leveraged during her experience at AMNH, with her Lang peers, and with multiple adult role models that she met during her 7 years in the program, helped her to forge an identity as someone who can do STEM. Similarly, Cody's repertoire of social interactions expanded throughout his Lang tenure and beyond, and helped him to clarify his STEM trajectory and to leverage his science social capital. Extending the term science capital to encompass science, technology, engineering, and mathematics, these youth show evidence of *STEM capital*, which we define as STEM networks and resources accessed to create positive outcomes.

Leveraging different forms of CCW to create and sustain social networks during adulthood

The three focal participants sustained the social networks they developed while in the Lang program and then forged ahead to make new connections with adults that they deemed critical for their STEM pathways. They also had a sophisticated understanding of themselves as learners and how to navigate through the college and career experience. When Lisa left the museum after graduating from high school, she said that she continued to seek out networking opportunities with other scientists. "[One] reason why I went to a liberal arts college", she reflected, "was because I wanted similar relationships that I experienced in Lang…to have a close-knit relationship with my professors and mentors." While Lisa found other aspects of her college challenging, she said that because of her Lang

experience, she felt comfortable seeking out professors for help and advice. She recalled: "There was a small student–teacher ratio so it was common for students to have lunch with their professors in the dining halls or even at the professor's house." Just as she does with her museum mentors, Lisa said that she still keeps in contact with her professors from her college and that a number of them continue to provide academic and career advice. Lisa's comfort with seeking out networking opportunities also helped her leverage social capital after she was hired to work at a major hospital. She said, "I think I have a closer relationship with the doctors and greater appreciation for them than my other colleagues do because I view them as my mentors."

Over the past two decades, Lisa has developed her navigational capital largely by accessing other forms of community cultural wealth, including her familial and social capital. Moreover, Lisa's individual agency, her perseverance, and her resiliency have been important attributes for navigating academic and career landscapes. In terms of familial capital, Lisa credits two key navigational traits to her family: "My friends call me a hustler and a negotiator. I think I learned that from my mom and my oldest brother because they had to hustle and do whatever they could to put food on [the] table." In terms of social capital, throughout her life—whether in middle or high school, at AMNH, in college, and in her place of work—Lisa has consistently sought out individuals to network with that could help her to access and successfully navigate academic and professional institutions.

Sage's trajectory took a different turn, but like Lisa, the people in her network were instrumental for her pathway. After Sage was separated from her college junior year, she could have easily given up. Instead, she reapplied to her college knowing that she would no longer be eligible for her research fellowship. Her former mentor from the college recommended that Sage consider a STEM teaching fellowship. Her mentor wrote a letter of recommendation for her, and Sage was awarded the fellowship. "It changed my life", said Sage. "Teaching was the thing that clicked for me. It ended up being a pretty [hesitation] funny path for me to get there. I'm just glad that I got there." Sage presently teaches mathematics in Philadelphia, Pennsylvania in a high school comprised of nearly 100% African-American students. Now that she is an educator, she said that she thought back to the adults who are strong role models for her—her middle school teachers, the Lang educators, and her high school calculus teacher:

> When I think about who it is that made me want to be a STEM educator, those people were really the driving factor. When I started thinking about why is it that I want to become a teacher or why it is that I want to be in STEM, I keep going back to those positive role models and those positive experiences.

She says that working with students has changed her life:

> I never felt so personally fulfilled from just like helping someone…that was something a lot of great people did for me and I feel like it's something I can do for a lot of kids, like make a difference in their lives, too.

Gender identity, CCW, and social networks

The construct of gender identity in STEM became an important thread for Lisa as her actions and experiences mediated her developing social capital. During high school, Lisa was required to complete an internship for credit. She recalled a female executive that "stood out" to her during this internship. Although Lisa never spoke to this executive, she admired her from afar:

> It was a very professional and corporate place. Everyone wore suits and ties and [they] were always busy. I distinctly remember people whispering anytime this female [executive] would walk by or into a room. Everyone was so afraid of her for some reason. One day, I walked by a conference room and noticed that she was the only woman in a room full of men. That image was captured in my mind for some reason.

Lisa said that this experience affected her deeply because it contrasted with her family life. "As the youngest, and a female", Lisa said, "I never really had the authority to voice my own thoughts and beliefs." Lisa recalled that when she was younger, many of her teachers and friends would describe her as shy, and while she became adept at networking with individual mentors as early as middle school, Lisa said that she remained reserved and quiet throughout college. When she was hired as a Clinical Trials Data Manager, Lisa said that the PI encouraged her to be more assertive: "I became drawn to women in power and became mesmerized at how assertive and powerful women could be. Being in an environment where women were in power continues to change and challenge me." In support of Lisa's "tendency to latch onto mentor figures", a recent study titled *Women in the Workforce* (Thomas et al. 2017) found that one reason why women are promoted at lower rates than men is because they are "less likely to receive advice from managers and senior leaders" (p. 10). This finding further accentuates the critical importance of building social networks and leveraging social capital through engagement with other practitioners of STEM, something Lisa practiced from middle school and beyond.

Theme 4: a continuum of STEM experiences

For all three participants, their STEM pathways were not a proverbial "pipeline"; instead, each described multiple entry and/or reentry points during their STEM pathway (Lyon, Jafri and St. Louis 2012). Moreover, all three focal alumni described significant challenges ranging from being separated from their college, feelings of not belonging, and fear of failure. A critical challenge encountered by all three focal participants was their decisions to transition from one STEM career to another: Sage transitioned from her aspirations of becoming a math researcher to becoming a math educator; Cody transitioned from research science to computer programming, and Lisa transitioned from clinical research to aspirations of becoming a medical doctor. We found evidence that as these individuals encountered these and other challenges, one reason for their capacity to persist in a STEM pathway was their ability to access the CCW they accrued from their families, extended families, and their museum network—in many cases maintaining sustained contact with their mentors and peers for many years, and leveraging these relationships to advance their academic and career goals. Flávio Azevedo (2011) describes these behaviors as "lines of practice", defined as "a distinctive, recurrent pattern of *long-term* engagement in a person's practice participation" (p. 147). To maintain lines of practice, each youth also described their capacity to broaden their capital by creating and sustaining additional networks in their college and career environments. Thus, we found overall evidence that each focal participant exhibited an aptitude for leveraging the forms of capital they accrued before and during their experiences at Lang, and then using these experiences to further accrue capital during STEM experiences in college and beyond.

Sage leverages different forms of CCW during her continuum of STEM experiences

Sage earned a scholarship to an all-women's college and decided to major in mathematics. She stated: "My participation in Lang influenced my decision to do research, to consider math research." During her freshman year, she received an undergraduate research fellowship and worked on a number of investigations including a research project on creating algorithms to help build sustainable energy resources and a coding project on fingerprints. Sage felt that her path was set. She planned to pursue a Masters and a Ph.D. in mathematics, and to pursue a career in academia. However, after separating from her college junior year, she modified her aspirations. After a hiatus, Sage reapplied to the same college. Although she was stripped of her research fellowship, she accessed her navigational and social capital to help transition from a STEM research track to a STEM teaching track. "They removed me from school and then I figured it out. I applied back to school. Another door opened. I got recommended for a teaching fellowship…It changed my life." Thus, even though Sage faced a number of setbacks during her academic trajectory, her familial capital, especially the educational and emotional support she received from her mother, and the aspirational, navigational, and social capital that she developed over the years as a Lang student and beyond, helped her to persist during this challenging period as she transitioned from one entry point to another (Fig. 1).

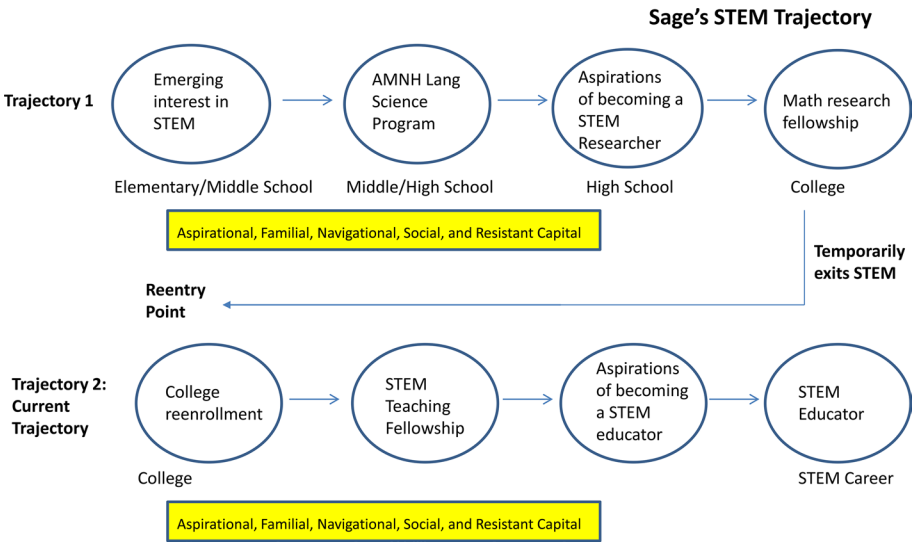

Fig. 1 A continuum of STEM experiences: Sage's STEM trajectory. Sage navigated multiple entry and reentry points during her STEM trajectory. Sage joined the Lang program where she had repeated experiences conducting authentic STEM research. She leveraged her aspirational, familial, navigational, social, and resistant capital to pursue her goal of becoming a STEM researcher. While in college, she received a prestigious math research fellowship and was on track to pursue a career in academia. However, Sage was separated from her college and took a hiatus from her education, and temporarily exited her STEM trajectory. Sage reenrolled in college, and leveraged her aspirational, familial, navigational, social, and resistant capital as she pursued a degree in STEM education. Sage is presently a STEM educator teaching mathematics in a public high school in Philadelphia, Pennsylvania

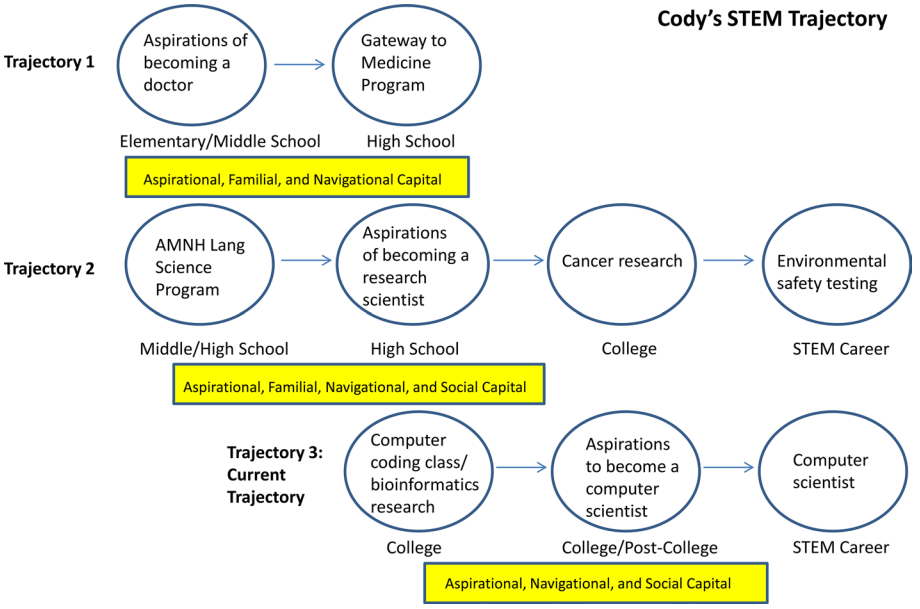

Fig. 2 A continuum of STEM experiences: Cody's STEM trajectory. Cody navigated multiple entry points during his STEM trajectory. During elementary, middle, and high school, he leveraged his aspirational, familial, and navigational capital as he considered a career in medicine. In middle school, Cody joined the Lang program where he had repeated experiences conducting authentic science research. During this period and beyond, he leveraged his aspirational, familial, navigational, and social capital to pursue a career in science research. In college, Cody took a computer coding class that inspired him to change his STEM trajectory. He taught himself to code, and then leveraged his aspirational, navigational, and social capital to pursue a new STEM pathway as a computer scientist

Cody leverages different forms of CCW during his continuum of STEM experiences

While Cody says that his interest in STEM has never wavered, his career aspirations have transitioned at least three times throughout his STEM trajectory (Fig. 2). First, up until high school, based on both his personal interest and his mother's encouragement, Cody leveraged his aspirational, navigational, and familial capital as he joined the Gateway to Medicine program at his high school. Second, throughout middle school and high school, Cody further developed his aspirational and navigational capital via participation in Lang, and he also leveraged his social capital as he interacted with AMNH educators and scientists at the Museum. During this period, he was exposed to different research experiences at AMNH, and by his senior year of high school, he transitioned from wanting to become a doctor to wanting to pursue a career as a research scientist. At his university, Cody worked toward this goal, and conducted research for the majority of his college tenure. Finally, when Cody was an upperclassman at his university, he registered for a computer programming class; here he was exposed to yet another career possibility, a career in computer science.

Cody now aspires to become a web developer and spends his spare time teaching himself computer coding: "I sort of transitioned from wanting to be a doctor [elementary school] into wanting to do more research [high school and college]…to web developer [post baccalaureate]." Cody felt that he was "too deep in [his] major to really make a

transition" so he decided to complete his degree in chemistry and work for the Department of Health following graduation. "I always heard stories about people teaching themselves to code", said Cody. Therefore, following graduation, he purchased several books on coding, found several online resources, and decided that he was going to teach himself how to code. When Cody is not at his full-time job, he spends his time learning computer languages: "It can be very time consuming trying to debug and figure things out on your own. It's good to struggle with things on your own and try to figure it out." Cody attributes his drive to succeed as a source of motivation:

> I really like…I just like being good at things. I really do want to get good at coding. It's like a drive that really helps me to push and try to be resourceful. And there are some times when I come across problems where I can't really find the answer and it's like I have to find a way to work around it, find an alternative.

Thus, while Cody experienced multiple transitions during his STEM pathway, his ability to leverage different forms of cultural wealth, including aspirational and navigational capital, helped him along his trajectory.

Lisa leverages different forms of CCW during her continuum of STEM experiences

While Lisa was encouraged to go to school and do well in her classes, she described a dichotomy between her school and home life: "There was always that pressure [to do well in school], but the home environment…education kind of stops in the classroom. I would say home wasn't conducive to studying at all and it was a lot about family, and familial duties." During the after school hours, Lisa was responsible for doing her chores and assisting her older siblings in preparing meals. Lisa recalled: "My mother was a garment factory worker, so we'd form our own assembly line at home to help our mother meet her daily quota or whatever it was she needed help". Previous studies of Asian American female adolescents have shown that there are sometimes tensions between familial expectations and personal aspirations (Ng et al. 2007). Indeed, Lisa recalled initially rebelling against her family's desire for her to pursue a career in medicine: "I was so resistant to do that idea when I was a kid because I didn't want to do anything my parents told me to do." To complicate matters, when Lisa was very young, her parents went through a difficult divorce; her father left and her mother needed to work multiple jobs to support the family. Therefore, her older siblings largely took over the role of caregiver throughout Lisa's formative years.

As a participant of the Lang program, Lisa was exposed to the scientific disciplines of AMNH, including many of the life sciences. Following this experience, she made a decision to major in biology when she went to college. During her senior year of college, Lisa leveraged her social capital and collaborated with one of her professors: she completed a senior thesis on kidneys and diabetes, which involved working in a laboratory studying diabetic mice. Following graduation, she leveraged her aspirational, navigational, and social capital, using her research experience to get hired by a major medical center as a Clinical Trials Data Manager. Here, Lisa realized that medicine was indeed her calling despite her earlier resistance to her parents' aspirations. She reflected:

> I think that because of the Museum, I kind of confined myself to the natural sciences originally, especially in college. So when I graduated college, I was really lost…I think there was such a huge focus on life sciences and natural sciences in the Museum and I was so into it that I figured like that, that would be the natural progression, to continue and to pursue a career in the life sciences. I decided to do medi-

> cine [after a friend] had a seizure and I accompanied him to the hospital in the ER. That was sort of my first interaction, seeing a physician just questioning the patient and I think I realized that how [the Lang program] encouraged us to ask questions and develop hypotheses and do our own experiment was similar to or could be transferred to medicine and I think that's what I really loved about medicine and that's what intrigued me years after.

While working full time, Lisa enrolled at a local college, began to retake classes, balancing the demands of a full-time job and other commitments: "I have found that I am much more capable of grasping the material, prioritizing my workload, organizing my time, enjoying my classes, and doing well in them." It has taken Lisa many years to reach this point, and while she has not yet achieved her goal of going to medical school, she has repeatedly accessed her aspirational capital to persist while in pursuit of her long-term goals. When asked if she ever thinks about giving up, she laughed and responded: "All the time, all the time, but when I think about other options, there's nothing else that I would want to do or could picture myself. It is how I really know that this is the path where I really want to take." She said that although it's a lot of hard work, she believes that her love for medicine and science is too deep: "I think about quitting all the time because it would be easier, but I try and do other stuff, and I just know I just won't be happy in any other career or field." By leveraging different forms of cultural wealth, especially her

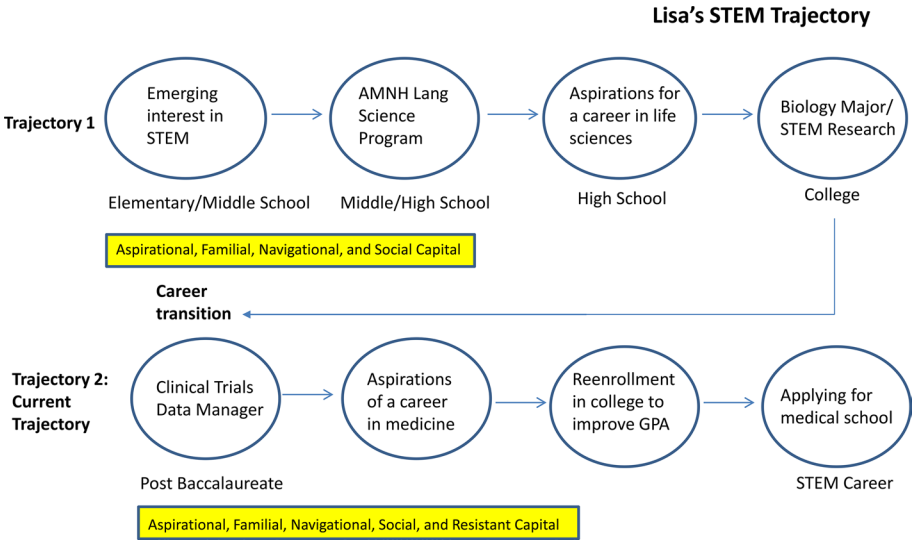

Fig. 3 A continuum of STEM experiences: Lisa's STEM trajectory. Lisa navigated multiple entry points during her STEM trajectory. During elementary, middle, and high school, she leveraged her aspirational, familial, navigational, and social capital as she considered a career in the life sciences with a specific interest in biological research. In middle school, Lisa joined the Lang program where she had repeated experiences conducting authentic science research, which influenced her decision to major in biology and to join a research laboratory in college. As a post baccalaureate, Lisa was hired as a Clinical Trials Data Management where she was responsible for coordinating leukemia trials. Her aspirations transitioned from a career as a STEM researcher to a career in medicine. She leveraged her aspirational, familial, navigational, social, and resistant capital to pursue a new STEM pathway. To achieve her goal of becoming a doctor, Lisa has reenrolled in college to improve her grade point average (GPA) and to prepare for the Medical College Admission Test (MCAT)

aspirational, navigational, and social capital, Lisa was able to transition from one STEM career pathway to another even when faced with challenges (Fig. 3).

Summary of four emerging themes

Here we summarize the four themes that emerged from this study to demonstrate the salient ways that the participating students leveraged and applied their cultural assets toward success and persistence in STEM.

Expanding the realm of possibilities: summary

For all three focal participants, their experiences at Lang afforded them opportunities to become practitioners of STEM. For example, in 1 year, students had the option of joining a field biology research team where they conducted avian research at a museum field site. Here, participants had the opportunity to imagine the possibility of becoming a field biologist or an ornithologist. In another year, Lang students had an option of joining a population genetics research team where they conducted authentic research in a museum laboratory. In this case, participants had the opportunity to imagine themselves as evolutionary biologists, geneticists, and bioinformaticians. Through this iterative process, the focal participants leveraged their CCW, forged their STEM identities, and expanded their realm of possibilities.

Maintaining resiliency while facing significant obstacles: summary

During their STEM trajectories, Sage, Cody, and Lisa accessed various forms of CCW. Critically, when faced with significant barriers, each demonstrated the capacity to remain resilient, and the wherewithal to leverage different strategies to overcome potentially crippling obstacles. Sage and Cody found strength in their familial and social capitals, leveraging strategies that they learned from their parents and drawing on the tools they developed in Lang to resist the temptation of giving up. Lisa and Cody dealt with issues of being a minority in their colleges; each leveraged their resistant and social capitals and galvanized the assets that existed within themselves: Cody and Lisa used these assets to make themselves stand out either physically (in the case of Cody) or through personality and action (in the case of Lisa). Thus, even though these three young adults faced critical challenges while negotiating the STEM landscape, by leveraging their assets, many of these barriers were overcome.

Creating and sustaining STEM social networks: summary

All three participants had an interest in science and ended up applying to Lang with the support and encouragement of different people in their network. Lisa's older sister was already in Lang and helped her apply. Lisa also convinced her best friend, who was also interested in science, to apply thus exerting her social capital to a peer. For Sage and Cody, their middle school teachers recognized their potential and suggested that

they interview for the Lang program. Once all three focal participants were in Lang, the social networks they had in their schools and communities, coupled with the social networks they developed through the Lang program, mediated their identities as people who practice science, and who promote science to others. These evolving identities as science people situated them to use their social networks in creative ways leading to new connections in college and beyond, and new ways of leveraging both the people they knew and the experiences they had to continue in their STEM trajectories.

A continuum of STEM experiences: summary

Sage, Lisa, and Cody's experiences during their STEM pathway differ from those described in the proverbial STEM pipeline, which implies that a STEM trajectory is a linear route from point A to point B (Lyon et al. 2012; Cannady, Greenwald and Harris 2014). Because variations in STEM pathways might be influenced by race, gender, ethnicity, and socioeconomic status (National Research Council 2011; Hammerness, Macpherson and Gupta 2016), it is critical that STEM scholars leverage the cultural knowledge and individual agency of youth from historically marginalized populations (Basu and Barton 2007). Therefore, the experiences shared by the three focal youth in the present study accentuate the critical importance of recognizing and supporting alternative pathways for building STEM scholarship and careers. This perspective is a paradigm shift from a deficit perspective, where youth who veer away from STEM are described as a statistic, part of the "leaky pipeline" (Alper and Gibbons 1993). Instead, there is a shift to an assets-based perspective, where STEM pathways are a continuum of opportunities, not viewed simply as a "lock-step trajectory toward STEM careers that fails to describe nearly half of all who end up in STEM careers" (Cannady et al. 2014, p. 445) and where different forms of CCW are leveraged to dispel negative stereotypes and to achieve long-term goals (Yosso 2005).

Research questions revisited

(1) What are the forms of CCW that the youth bring to and enact in the museum program?

Based on our interview data, we found that each of the three focal participants entered Lang with an array of CCW stemming from many sources including their families, extended families, and communities. All three participants credited their immediate families as sources of aspirational and familial capital and expressed that these two forms of wealth were critical for supporting their sustained participation in Lang and persistence in STEM in subsequent years. Sources of linguistic, social, and navigational capital were largely rooted from focal participants' interactions with their families and extended families, but also stemmed from their local communities and included critical interactions with influential adults in their neighborhood schools. During their long-term participation at AMNH, the three focal participants further leveraged aspirational, navigational, and social capital via multiple channels. Over this 7-year-period, they were offered exposure to and preparation for a variety of STEM majors and careers, which were influential in the additional development of their aspirational capital. Moreover, participants interacted with a vast network of AMNH educators and scientists as well as like-minded peers all of which were influential in

further augmenting their social and navigational capital. For at least some of the focal participants, and most particularly Sage, participation in Lang helped to build resistant capital as she perceived her engagement in this long-term program as a "game-changer" and an opportunity to "level the playing field." Overall, our interview data provided evidence that the focal participants entered the museum with unique CCW that mediated how they perceived their experience, ultimately mediating changes in their evolving identity as practitioners of STEM.

(2) In what ways do the youth use their CCW to navigate their STEM trajectories?

Following their participation in Lang, all three alumni accessed their museum networks leveraging their aspirational, navigational, and social capital to advance their academic and career goals. Each focal alumnus told stories of how they developed and maintained sustained STEM social networks with members of their Lang cohort and with AMNH educators and scientists. For example, all three youth accessed their museum network by contacting their mentors for college and career advice, and they used these relationships to attain letters of recommendation and to secure research internships. Despite individual differences in their personalities, the three focal alumni described an increased level of comfort and mastery in leveraging and extending different forms of CCW in college and beyond. While the three focal alumni expressed how participation in Lang was instrumental for drawing out different forms of CCW, one form of capital—resistant capital—was largely leveraged following their museum tenure: Sage accessed her resistant capital in college by seeking out a community of women of color with a shared interest in STEM. Lisa leveraged her resistant capital by taking on leadership positions, resisting feelings of inadequacy, and countering stereotypes of Asians. Cody used his identity as an African-American male to his advantage by making sure that professors recognized him for his positive academic contributions. Hence, we found overall evidence that each focal participant exhibited an aptitude for leveraging the forms of capital they developed before and during their experiences at the Museum, and then using these experiences to further leverage and expand their capital in college and beyond.

(3) What are existing design features of the museum program that leverage and cultivate the youths' existing CCW?

We learned that there were three salient design features of the Lang program that were particularly important for leveraging the various forms of CCW: (1) long-term participation; (2) research teams; and (3) multiple and repeated opportunities to interact with a variety of AMNH scientists and educators (Table 2). First, because the Lang program is a 7-year program extending throughout middle school and high school, participants had a long time to develop relationships and to feel a sense of belonging to the program and to AMNH. Without this multi-year experience, it would have been more challenging for youth to leverage their social capital and to form long-term networks with their peers, as well as museum scientists and educators. For example, when Cody was trying to secure a research position at his university, he was able to leverage his relationship with his AMNH research mentor, who worked with him to develop a cover letter and curriculum vitae. This was possible because Cody and his mentor developed a sustained relationship over multiple years. Second, participants of Lang had repeated opportunities to "try on" different science identities via participation in research teams (Habig et al. 2018). This design feature afforded multiple entry points for students to engage in authentic research alongside scientists. For example, Lisa engaged in varied research experiences—an earthworm ecology study in Prospect Park, Brooklyn; an oyster restoration project on the Hudson River; and an insect biodiversity survey in

Table 2 Design features of the Lang program that were important for leveraging community cultural wealth

Design principle	Examples from case studies
Long-term participation 7-year program 165 contact hours annually Summer and Saturday programming	Cody, Lisa, and Sage participated in Lang throughout middle and high school allowing a long time for them to leverage social capital and to develop and maintain sustained social networks Sage developed her social capital by forming a network with members of her Lang cohort, which has been a continuous source of support for her throughout her STEM trajectory extending well beyond her tenure in the Lang program Cody leveraged his social capital by contacting his long-term research mentor at Lang to help him craft a cover letter and curriculum vitae and in turn activated his aspirational and navigational capital to secure a research position at his university Lisa developed decades long relationships with AMNH educators and leveraged her aspirational, navigational, and social capital to attain help with exploring careers, developing contacts, and for navigating her STEM trajectory
Research teams Annual opportunities to engage in authentic research projects Develop research questions; formulate hypotheses; collect, organize and analyze data; communicate results	During their tenure at Lang, Cody, Lisa, and Sage had repeated opportunities to engage in authentic science projects and to try on different science identities Following participation in an advanced research team, Cody became interested in a career as a research scientist and leveraged his aspirational, navigational, and STEM capital to secure a position as an undergraduate cancer researcher upon graduation from the Lang program While in Lang, Lisa participated in an authentic research project and leveraged her aspirational and STEM capital by entering and then winning a national science research competition Sage expanded her realm of possibilities by leveraging her aspirational and STEM social capital via participation in an inquiry-based research project on the flight patterns of pigeons in her neighborhood
Multiple and repeated opportunities to interact with AMNH scientists and educators Coursework Behind-the scenes tours College and career readiness	Cody, Lisa, and Sage had multiple and repeated opportunities to interact with AMNH scientists and educators via participation in different workshops that parallel AMNH research disciplines, behind-the-scenes tours, and college and career readiness modules Sage leveraged her linguistic capital to develop relationships with AMNH scientists and educators who shared a common language and heritage Lisa leveraged her social capital and STEM capital to convince a retired AMNH educator to help her preserve a brown bat that she found in a local park and to put it on display in an exhibit Cody leveraged his aspirational, navigational, and social capital by asking an AMNH educator, whom he interacted with repeatedly, for a letter of recommendation for college

Van Cortland Park in the Bronx—each of which afforded her repeated opportunities to leverage her aspirational, navigational, and social capital. Lastly, the Lang program was intentionally designed so that participants had multiple and repeated opportunities to interact with a variety of AMNH scientists and educators. Many ISE programs, especially those that are designed for short-term engagement, provide participants with opportunities to interact with one or a few educators or scientists. During Lang, students had repeated and varied interactions with a multitude of educators and scientists via participation in different workshops and modules centered on the different AMNH research disciplines. For example, Sage recalled an experience during Lang when a female Hispanic scientist, an ichthyologist (a scientist who studies fishes), gave a presentation on her research:

> That was one of those moments. There are people who look like me. There are people from my background doing the things that I want to do…I have other people that speak Spanish…that are Hispanic, that are…able to do these things that I want to do. I think that kind of influenced me in that sense.

Sage stated that her Hispanic heritage afforded her opportunities to develop social networks at AMNH: "I do feel like being Hispanic has opened up doors, and also opened up conversations between other Latin American scientists or Latina/o identifying individuals." Thus, through repeated and varied interactions with a variety of educators and scientists, Lang youth had many opportunities to leverage several forms of CCW, in Sage's case, her aspirational, navigational, social, resistant, and linguistic capital. Collectively, our results suggest that long-term programs with varied, authentic research experiences that incorporate multiple and repeated opportunities to interact with scientists and educators, are design principles that maximize opportunities for participants to leverage their CCW.

Contributing to theory and practice

In this study, we centered the assets that youth brought to a museum-based program and how they used those assets to navigate the program, build additional capital while forging a STEM identity, and then leveraging their capital beyond the program toward participation in STEM majors and careers. This analytical approach not only highlighted students' assets, but also allowed us to think about the diverse places that students learn and interact with STEM as well as the networks that cultivate and sustain their STEM-related interests and identities.

As program designers and educators, it is first important to elucidate and challenge the assumptions that we make around program design and enactment, especially when programs are structured around goals of broadening participation or narrowing the achievement gap in science. This also means challenging the underlying premise of enrichment: that it should not be structured around niceness and creating opportunities where none exists, but rather it is a way of augmenting strengths toward greater equity and achievement. In the last several years, professional learning programs for informal learning staff and leaders have begun to focus on supporting this shift in thinking and practice. Programs that work at the institutional level such as the Cultural Competency Learning Institute (https://community.astc.org/ccli/home) and iPAGE (https://www.smm.org/ipage) have served numerous institutions in revamping their strategy and developing a plan for

organizational change. The Reflecting on Practice (RoP) program (http://reflectingonpractice.org/) has made strides in working with informal learning staff, including front-line educators, in thinking about issues of equity and access from the perspective of how people learn and on how to enact practices that break down structural inequalities. These programs have been essential for transforming how designers and educators approach informal learning by engaging staff in readings, discussions, and activities that intentionally disrupt the deficit narrative allowing for unpacking of ideas, reflective thinking, and collaborative approaches to developing asset-based pedagogical practices.

This study is a step in the positive direction of viewing youth, youth of color in particular, from an asset-based perspective. This allows us to think differently about science enrichment programs and allows us to frame the structures of programming around issues of leveraging existing capital rather than augmenting deficits. This would require us to learn more about the young people that programs target, learning more about the communities from which they are recruited, the families that they come from—with an emphasis on what exists rather than what is perceived as missing—and most importantly, listen to the young people when they tell you who they are. For this latter point, program designers could learn a lot by structured dialogues with young people both as a part of the entry process and continuously throughout the program that allows interested adults to learn more about the youth as people—their identities and visions of future self. In turn, this allows the young people to learn with and about the adults in ways that build social capital and more ideas about different ways of participating in science.

Central to an asset-based perspective of young people is structuring opportunities for participants to access resources and build a sense of agency in pursuit of visions of their future selves. Visions of future selves are a part of the critical identity work that is experienced by all young people—the ongoing work of finding their place and roles in the flow of social activities. In enrichment programs, youth should be positioned as leaders in this activity irrespective of their racial, socioeconomic, immigration, or gender backgrounds.

Limitations

One limitation of these findings is that the application of the case study method, while allowing for richer and greater depth of data, cannot necessarily be generalized to a larger population (Merriam 1988). However, Robert Yin (2009) posits that case studies, especially multiple cases, are instructive for identifying patterns and Bent Flyvbjerg (2006) argues that case studies are particularly critical for generating the best theory. A second limitation is that the focal participants of this study exclusively shared positive experiences with respect to their participation in the AMNH Lang program and all three, despite encountering difficult challenges, persisted in their STEM trajectories. John Creswell (2013) recommends the use of disconfirming cases in qualitative analyses. We think that the recruitment of an alumnus or alumni who had negative experiences with the program, who did not complete the program, and/or who did not persist in a STEM trajectory might help us better understand the intersection between CCW theory and ISE programs, and may have helped us further identify missed opportunities. It is our intention to follow-up with such alumni in a future study. Lastly, although our interviews were extensive and included numerous follow-up conversations and email exchanges, due to the retrospective nature of this study, we recognize that we may not have completely captured the CCW that youth brought to the museum program and beyond.

Conclusions and future directions

Our motivation for conducting this research study was based on our intent to move away from a deficit lens and work toward drawing on the knowledge and skills youth bring from their homes and communities into the museum program. Further, while participating in this process, we recognized that it is also important to move beyond creating theory and work toward practical application of theory (Yosso 2005). Therefore, we used this experience to reflect on where we have been consistent in drawing out youths' CCW and where we have missed opportunities in this regard. Our data indicate that while there is certainly room for improvement, Lang educators have satisfactorily leveraged participants' aspirational, navigational, and social capital. For example, youth in Lang are repeatedly encouraged to contact scientists and to meet with AMNH educators to work on their college applications and to discuss their career goals. Since this is embedded in the program design, Lang youth can readily activate their aspirational, navigational, and STEM social capital on a regular basis. However, our data also indicate that there were missed opportunities in terms of drawing out youths' familial, linguistic, and resistant capital. For example, while our interview data revealed that familial networks were key factors contributing to each focal youth's persistence in STEM, we also found that there were limited opportunities for parental engagement and that more can be done to leverage youths' familial capital in the Lang program. We believe the next important step is to reevaluate and revise the program curriculum to ensure that educators are providing a supportive environment for leveraging all six forms of CCW. Thus, some of the next important steps will be to provide professional development on facilitating a culturally relevant curriculum, to apply practices embedded in the curriculum that draw out CCW of the youth, to connect students with organizations that have a track record of leveraging CCW, and to leverage alumni supports to foster youths' pathways toward STEM careers.

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