

Designing STEM Learning Environments to Support Middle School Black Girls' Computational Algorithmic Thinking: A Possibility Model for Disrupting STEM Neoliberal Projects

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This study reports findings from a longitudinal study aimed at supporting middle-school Black girls' computational algorithmic thinking (CAT). We argue that STEM learning, in the way SCAT designs it, is not about neoliberal aims, but provides Black girls with opportunities to radically shape their identities as producers, innovators, and disruptors of deficit perspectives. Using Black Feminist Thought and Intersectionality as a theoretical lens, findings suggest Black girls participate in SCAT in order to find *meaning in relevance and altruism, author their own creative imaginations, and create new narratives about themselves and other Black girls and women.* Implications for K-12 are discussed.

The complexities of Black girls and the neoliberal STEM project

Black women and girls are rarely constructed as producers of computer science knowledge in U.S. schools and society (Thomas, Joseph, Williams, & Burge, 2018). Schools and society do not view Black girls as STEM producers in large part because they have historically occupied the lowest social status in the U.S. (Collins, 2000) and have been positioned as intellectually inferior in STEM. Such positioning of Black girls can be conceptualized as a manifestation of a failing STEM educational infrastructure that promotes exclusion and perpetuates intersectional oppressions, such as gendered anti-blackness (Vargas, 2012). Design, learning, identity, and teaching are inextricably linked and should come together in ways that produce and promote robust experiences for participation in a global world; yet many Black girls, particularly in STEM environments, are rarely served in such ways (Ireland, et. al., 2018).

Some scholars have argued that STEM is simply a neoliberal project that is not in service of full richer lives, but economic gains and power. We think that scholars who position themselves in this way speak from places of privilege and may not understand the deeper social-political contexts for many families who dream of a different life for their children in terms of economic mobility. This narrative about the desire for more STEM in our schools and society as an economic, social, cultural, or historical organizer of human society requires a closer interrogation of the nature, purposes and outcomes associated with STEM learning across time, contexts, and people. When we put this narrative in conversation with mixed-income middle school Black girls' experiences in an informal learning environment designed to promote Black excellence, a more nuanced and complex perspective emerges.

We examine the following research questions: (1) What do SCAT Scholars reveal about what they learn and why they participate in SCAT? and (2) How do their perceptions of themselves as game designers shift over time as a result of their participation in SCAT? We share findings from a longitudinal study exploring the development of computational algorithmic thinking capabilities in Black girls as they engaged in game design for social change.

SCAT's epistemological orientations: Black feminist thought (BFT) and Intersectionality

Within the field of education research, much of what we know about STEM learning emerges from a range of epistemological frameworks, theories, and methodologies; yet Black girls have not been the focus of that theorization. We draw upon BFT and intersectionality to contextualize the roles that inequality and hierarchy play in the unequal distribution of learning, opportunities, and outcomes, specifically in computing. Black Feminist Thought (BFT) is an epistemology and politic that suggests that African-American women's oppression has encompassed three interdependent dimensions: economic, political, and ideological (Collins, 2000). The economic dimension of oppression illuminates the "exploitation of Black women's labor that has been essential to U.S. capitalism from the very beginning of slavery, leaving little room and opportunities to do intellectual work as it has been traditionally defined" (Collins, 2000, p. 4). The political dimension helps us see the historical and contemporary denial of rights and privileges to Black women that have been routinely extended to both White males and females, ideas that extend into STEM classrooms for Black girls (Joseph, Hailu & Matthews, 2019). The ideological dimension refers to the historical and present-day control of images applied to Black girls.

Intersectionality emerges from BFT and was coined by Crenshaw (1993) who sought a way to correct the legal discrimination Black women faced due to the legal system's focus on a *single categorical lens*. Girls in STEM often means that the needs of white girls are centered, and African Americans in STEM often means that Black males' needs are emphasized (Malcolm, et. al., 1976; Ong, et. al., 2011; Charleston, et. al., 2014). We use intersectionality to better understand a more nuanced picture of Black girls' experiences in SCAT.

Supporting Computational Algorithmic Thinking (SCAT): Where Design, Cognition, and Identity Intersect to Create a “Wakanda Affect” Situated in Black Excellence

SCAT is an NSF-CAREER longitudinal research study and free enrichment program for exposing Black girls (i.e., SCAT Scholars) to game design, an industry in which they are critically underrepresented. SCAT centers Black girls' development of computational algorithmic thinking (CAT), a scaffolded on-ramp to more advanced computational thinking (Thomas, 2015; Wing, 2008). Scholars began the program the summer prior to their sixth-grade year and have continued through what is now their twelfth-grade year. They took part in three types of activities each year (called a SCAT Season): (a) a two-week intensive game design summer experience where Scholars work in groups of two (dyads) to design a game for social change; (b) twelve technical workshops where Scholars implemented the games they designed using visual and programming languages in preparation for submission to national game design competitions; and (c) field trips where Scholars learned about applications of CAT in different industries and careers. Scholars also had several scaffolds to support them in the ways cognitive apprenticeship suggests (Collins, Brown & Newman, 1989; Thomas, Rankin, Minor & Sun, 2017).

The facilitator (a Black woman Ph.D. in Computer Science) played a major role in the development of Scholars' CAT capabilities, serving first as the primary modeler and then as a just-in-time coach and scaffolder (Collins, Brown & Newman, 1989; Thomas, 2015). She was assisted by four undergraduate Black women majoring in Computer Science who also served as coaches. The Design Notebook (paper-and-pencil based scaffolds for dyads and individuals) was integrated into SCAT activities, affording Scholars multiple opportunities to develop CAT capabilities while working individually and collaboratively in dyads over time (Thomas, et. al., 2017; Collins, Brown & Newman, 1989; Owensby, 2006; Vygotsky, 1978). Finally, dyads who were further along in the game design cycle supported others who were not (Wells & Chang-Wells, 1992). SCAT's design leverages and integrates an informal, intersectional, cognitive apprenticeship learning environment that centers, supports, and elevates Black girls as they develop CAT capabilities in the context of designing games for social change (Crenshaw, 1993; Collins & Bilge, 2016; Collins, Brown & Newman, 1989).

Methods

Data sources and analysis

Data sources included analysis of online journal data and end of season questionnaires across the first three years of SCAT. Scholars completed a journal entry each time they met for SCAT activities (summer experience and workshops) each Season. The online journal was created using a google form to make capturing the responses easier. Scholars documented their goals and assessed those goals including thinking about what supported and got in the way of accomplishing their goals. The end of season questionnaire (also a google form) was designed to provide insights into Scholars' perceptions and feelings about their SCAT experience, their understanding of CAT, their perceptions of themselves as game designers and the application of concepts learned in SCAT to other areas of their lives outside of SCAT.

We utilized Consensual Qualitative Research (Hill, Thompson, & Williams, 1997) to both collectively and individually analyze the data and come to consensus on the themes. The first cycle of coding included tags very close to the data. A second round of coding collapsed similar tags to create larger categories. A third round of coding identified patterns from previous codes/categories to develop larger theoretical themes. Finally, how their perceptions shifted over time included analyzing responses to the online end-of-season questionnaire prompt, “Do you see yourself as a game designer? Why or why not?”. We counted the number of Scholars who stated that they did (yes), did not (no), or weren't sure if (maybe) they saw themselves as game designers. Analysis of this prompt for Season 1 is described in (Thomas, 2015). In this paper, we include data from Seasons 2 and 3 and discuss trends across three Seasons. Overall, memoing was an ongoing part of the analysis, and we used Black feminist epistemologies and intersectionality to situate and interpret the findings.

What do SCAT Scholars reveal about what they learn and why they participate in SCAT?

Analysis suggests that, initially, some engaged to please their parents and families, while others had authentic interests in exploring STEM (though not necessarily computing) as a future career from the beginning. SCAT provided opportunities for the girls to imagine something bigger, bolder, and beyond the basics of just consuming technology to producing technology, such as a game to address a social issue they saw in their communities. Analysis showed that they participated in SCAT in order to find *meaning in relevance and altruism*. One participant commented, “I would make a mini level to give the food to homeless people,” while another one stated, “I like the problems it addresses and I like the fact that it can be applied to daily life.” Analysis also revealed that Scholars participate in SCAT because they can *author their own creative imaginations*. One participant stated, “[game design] allows you to bring new concepts and stories to the table.” This statement contends that Black girls do produce knowledge while developing their own complex games and that the activities allow them to bring their own ideas that may differ from others, autonomy and agency that formal school settings rarely provide Black girls. Finally, analysis illuminated that SCAT helps them to *create new narratives about themselves and other Black women and girls*. One Scholar said, “Overall, this is one of the greatest experiences I’ve ever been exposed to as an African-American woman” and a different participant stated, “at the beginning of SCAT, I didn’t understand why I was there. Then I thought about what I was doing. I was an African American girl learning how to properly learn game design. As I grew over the years in game designing, I gained a strong liking. The SCAT program has gifted me with a new hobby that most women don’t have, and for that I am grateful.” These statements suggest that middle school Black girls are aware of the ways schools and society have limited their exposure to STEM, and they see how SCAT supports them to envision what can be for themselves and other Black girls.

How do their perceptions of themselves as game designers shift over time as a result of their participation in SCAT?

As described earlier, the end of Season questionnaire was administered at the end of the first three Seasons. Thomas (2015) describes how Scholars’ perceptions of themselves as game designers shifted at the end of the first Season, and this article describes how Scholars’ perceptions shifted over all three Seasons. At the end of Season 1, while most Scholars saw game design as a viable hobby, none of them saw themselves pursuing game design as a career, suggesting that Scholars equated seeing themselves as game designers to wanting to pursue a career in game design (Thomas, 2015). However, by the end of the second Season, 23% of Scholars shifted from not seeing themselves as game designers to now seeing themselves as game designers. At the end of Season 3, the percentage of Scholars who saw themselves as game designers increased to 45% (e.g., “Yes, because over the three years I feel like I’ve gotten better and better with designing games and if I kept going I imagine what I could do”).

Conclusions

So, what do these findings suggest about the STEM neoliberal project and Black girls’ learning in the context of computing? These findings suggest that STEM learning for whom and to what ends is a complex narrative when centering Black girls because of the intersectional politics of their histories and STEM education opportunities. Scholars did not indicate that any of their motivations for engaging in SCAT had to do with economic gains. STEM learning, in the way SCAT designs it, is not about neoliberal aims, but provides Black girls with opportunities to radically shape their identities as producers, innovators, and disruptors of deficit perspectives. This often does not happen in formal settings; thus, SCAT serves as a counter-space for STEM learning. Research findings bear great significance for K-12 education, both formal and informal settings. First, Black girls’ should be positioned as producers of knowledge in STEM. This means that educators must relinquish their biases that prevent Black girls from seeing themselves as belonging in these spaces. Second, Black girls need to have not only opportunities to acquire and develop STEM skills, capabilities, and practices, but they also need time to reflect on those opportunities and experiences and assess whether and how STEM connects to their own interests, goals, and aspirations. It is imperative that learning scientists think from an intersectional perspective when considering how to design STEM learning environments for Black girls. As a field, we must acknowledge that this work has not been done, and if we care about educational equity for all students, this is the work. Our research is just one example to promote a national discourse about how STEM learning changes when Black girls are present and what we can do to better support their thriving in STEM contexts and spaces.

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