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Promoting and Supporting Computer Science Among Middle School Girls of Color: Initial Findings from BRIGHT-CS

Abstract

The purpose of this paper is to present initial findings about the features of effective learning ecosystems to nurture interest in computer science (CS) among middle school girls of color. Using qualitative data, we examined how the BRIGHT-CS ecosystem model—which combines a cohort structure, culturally empowering curriculum and mentoring from women and persons of color—can motivate steps toward “possible selves” in CS among girls of color with prior CS interest. After four months of implementation, student interviews indicate that an effective CS learning ecosystem nurtures “possible selves” by 1) leveraging and building peer relationships, 2) creating mentor interactions that support persistence through CS-related challenges, and 3) providing opportunities to generate authentic evidence of one’s own potential in CS.

Promoting and Supporting Computer Science Among Middle School Girls of Color: Initial Findings from BRIGHT-CS

Objective

Black college freshman interest in computer science (CS) has been declining for almost 20 years—to an all-time low of 9% in 2014 (National Science Board, 2016). There is clearly a need to start integrating CS into the K-12 public education system earlier, when Black students and parents are highly interested in learning about CS (Google Inc. & Gallup Inc., 2016).

Given the pervasive gaps in school performance, discipline, and services they experience (Blanchett, 2006; Grissom & Redding, 2016; McFarland et al., 2018; Nord et al., 2011; United States Government Accountability Office, 2018; Zhang, Katsiyannis, Ju, & Roberts, 2014), interest and support from parents are not enough to promote more equity in CS . Black students face structural, instructional and curricular barriers to accessing CS, as evidenced by fewer opportunities to learn computer science at school (Google Inc. & Gallup Inc., 2015b); a "deeply flawed" computer science teaching certification process (Computer Science Teacher Association, 2013); limited professional development for CS teachers; and "whiteness" in math (Battey & Leyva, 2016) and science curricula (Le & Matias, 2018; Mensah & Jackson, 2018) that advances a racial hierarchy of math and science ability (Battey & Leyva, 2016).

This paper presents initial findings of a program designed for middle school girls of color, and specifically Black girls.[1] The Building Student Retention through Individuated Guided CoHort Training in Computer Science (BRIGHT-CS) program creates a comprehensive computer science and empowerment model by building partnerships with schools, universities, non-profit, and community organizations in a local area. We recognize that to engage Black girls in computing, we cannot rely on "one-off" experiences such as a coding day, a Hackathon event, or a coding camp—where effects fade over time (Bailey et al, 2017). Instead, engagement must be an on-going process that is part of a larger learning ecosystem of students, parents, community, and school.

This study's guiding research question is: What are the features of an effective CS learning ecosystem to promote and support interest in computer science among middle school girls of color?

Theoretical Framework

Research demonstrates that 'deep learning' develops across multiple settings and timeframes; learning is not limited to the school structure or day. This type of deep learning and engagement is leveraged when resources are aligned in a STEM learning ecosystem (National Research Council, 2015; Traphagen & Traill, 2014). Building on the NRC model of a STEM Learning Ecosystem, our theoretical framework outlines a CS learning ecosystem specifically for middle school girls of color.

[1] Our reference to "Black girls" includes students of African origin or ancestry, including but not limited to African American, African immigrant, Hispanic non-White, and Caribbean.

The BRIGHT-CS model starts with a cohort of girls of color from the same middle school. This cohort of girls goes through a 9-month afterschool program at their school and a two-week summer experience at local university or non-profit. The curriculum infuses cultural empowerment and leadership skills, where the focus is on solving problems with technology. In addition, the girls receive mentoring from women and persons of color who are local community leaders, computer scientists, and entrepreneurs. As an ecosystem, the program partners with schools, community organizations, and local universities to provide an engaging experience for girls and their families.

Methods

Sample

The sample is composed of 46 students from four urban middle schools (two each in New York and Virginia). These students applied to be part of the BRIGHT-CS program between November, 2018 and the program launch in January, 2019. Of the 46 students, all are girls except for one boy. Demographic information is available in table 1.

Benchmarking against a national sample of 771 girls surveyed by Google and Gallup on attitudes and experiences in computer science, there were marked differences in the BRIGHT-CS students (see Figure 2). First, over 2 in 3 BRIGHT-CS students were told by teachers and parents that they would be good at computer science (63% and 65% respectively), compared to the benchmark sample of only about 1 in 4 girls. The BRIGHT-CS students were also very interested in learning CS (37%) compared to the benchmark sample (16%), and very confident in learning CS (72%) compared to the benchmark sample (48%). Differences are not surprising given that, unlike the benchmark sample, BRIGHT-CS students self-selected into a CS program.

Data Collection

As a multi-method study, we collected both quantitative and qualitative data among students who had parental consent. First, we obtained the quantitative data during the student application process. In the application, we gathered student demographic data, perceptions of math and reading taken from the NCES Education Longitudinal Study survey and experiences in computer science taken from the Google/Gallup survey (Google Inc. & Gallup Inc., 2015a).

Qualitative data was obtained during the BRIGHT-CS program activities and included interviews of students, parents, community mentors, school sponsors, and program instructors at multiple timepoints. In addition to the interviews, we collected program documents, computational artifacts and afterschool session observations.

Analysis

Qualitative data (i.e., notes taken during observations and interviews, artifacts, and documents were digitized. Then, the primary research team created a “start list” (Hill et al., 2005; Hill, Thompson, & Williams, 1997; Saldana, 2009) based on the main components of the project and moved into core ideas, themes, and cross-analysis (Huberman & Miles, 1994). We will obtain feedback on the initial results of the themes from the participants during the auditing process for validation or "trustworthiness" (Hill et al., 2005; Hill et al., 1997; Morrow, 2005). The results will be finalized after triangulating data, data sources, and confirmation of the consistency of results.

Results

In addition to increased computational thinking (CT)/CS skills and knowledge, the intended student-level outcomes of the BRIGHT-CS model include sustained CT/CS interest and pursuit of rigorous coursework, including courses in CS.

After four months of the BRIGHT-CS afterschool program, some students reported greater feelings of commitment to pursue coursework or careers in CS or STEM. Many students also reported increased technical skills in coding, but they appear to continue to have limited understanding of what computer science is beyond coding. Besides coding skills, one of the other most commonly reported outcomes of the program was increased relationships with other girls in the program.

Student reflections on the afterschool program model – including the cohort structure, mentoring from professionals, and a CS curriculum that seeks to build empowerment – illustrate how the model worked to shape these results.

<u>Cohort structure: "Some I know well, and some I get to know through this program."</u>

Each site started with a cohort of between 8 and 15 students. However, attendance challenged most sites. Ultimately, the number of students who completed the program ranged from 5 to 11 per site. Among completers, data suggest that it mattered less to recruitment and retention that the cohort consisted of girls or students of color, than that it included at least one close friend. One student, who initially had little interest in CS, summarized, "I'm kind of close with… half the girls; doing it with them makes it more fun." Asked how to interest other girls in joining or staying in BRIGHT-CS, multiple students shared the sentiment, "I never want to do something alone… I recommend telling girls to bring their friends."

Once students were in the program, however, it became important to girls to work in teams with girls they didn't know well. According to multiple students, this allowed them to develop "bonds" that expanded their network of school friends who share their interest in CS, especially when it involved working toward a common goal (e.g., developing a web application, as students did in 3 of 4 sites). "I liked cooperating with other girls who had interests in coding or STEM," one student explained. "Through this project… I really like how I got to expand my circle of friends and now when I see them in the halls , I feel connected to more people," said another.

<u>Empowerment: "I now see that my brother is not the only one who can code; I can too."</u>

The BRIGHT-CS curriculum aims to develop the social-emotional attributes that empower girls of color to persist in the disproportionately white and male field of STEM-CS. As one BRIGHT-CS mentor noted, "[STEM-CS] isn't a very welcoming field [for us]. Being confident in your abilities and skills to learn" are key success factors.

CS curricula often rely on examples of women in STEM or activities that foreground non-white cultures to develop a sense of empowerment. While representation in the curriculum matters, data from BRIGHT-CS suggests that more fundamentally, girls of color wanted curricular opportunities to generate personal evidence that *I can do CS*, by discovering or teaching others their existing CS skills (e.g., problem-solving) and by creating their own "real-life" CS product or solution. As they invariably encounter gaps in their skills through these activities, they also needed to experience intrinsic motivation to pursue needed learning independently—which can be nurtured through opportunities to work on a product that matters personally to them.

Girls associated these opportunities, more than any other learning activites, with feelings of empowerment, as illustrated by one student who said, "It helped me do my best in certain skills that I've never seen before in myself. I didn't know I had it until I saw that I could solve the problem... Here, we are doing things we actually want to do from real life. We had a purpose… [Now,] I'm thinking of using my skills in coding to promote an app. I'll probably take another class first because I'm still learning."

<u>Mentoring: "They help me with ideas."</u>
A number of girls reported leaving the first semester with a stronger commitment to pursuing coursework or careers in CS or STEM. Data suggest that the mentoring experience was a major factor in encouraging girls to take these steps towards "possible selves" in CS (Markus & Nurius, 1986; Oyserman, Bybee, and Terry, 2006).

However, as with the curriculum, data indicate that girls need more than just exposure to women in STEM. In contrast to simply talking to their mentor, a number of girls promoted the idea of enlisting their mentor's support to navigate a problem they might encounter in CS. For instance, one student said, "My mentor helped me figure out my code, because it was messed up… We were in the meeting and I asked other friends if they could help, [but] they couldn't… She asked what are you doing, I said fixing my code, and she asked to help."

Significance
BRIGHT-CS participants were highly interested and confident in learning CS, but, as national data indicate, these attributes are not enough to guarantee persistence in CS—as reinforced by the number of participants who left the program during the first semester.

Oyserman and her colleagues find that to commit effort to a possible self, students must believe the self is possible to attain, learn to interpret difficulty encountered as normal or key to achieving that self, and experience social support for developing specific strategies to press forward (Oyserman et al, 2006; Oyserman, Gant, and Ager, 1995).

Student reflections indicate that programs like BRIGHT-CS can support efforts toward possible selves in CS – like the independent pursuit of learning and plans to pursue CS coursework and careers that we observed – by incorporating:

- **Curricular opportunities to generate a real-life CS product.** By generating evidence that *I can do CS,* these opportunities demonstrate to girls that a self in CS is possible to attain.
- **Mentoring where they partner with a CS professional to solve a CS problem.** Focusing mentoring on navigating an authentic problem normalizes difficulty and creates social support for developing specific strategies to press through difficulty in CS.
- **Strategic teaming in pursuit of a common goal that helps girls develop new friendships supportive of their interest in STEM-CS.** Girls with friends who demonstrate achievement in STEM are more likely to pursue advanced coursework in STEM (Riegle-Crumb et al., 2006). Additionally, programs can support the preliminary step of persisting in the program by using recruitment that targets pairs or triads of friends (rather than individuals).

Table 1: Demographic Characteristics of BRIGHT-CS Students

DEMOGRAPHIC INFORMATION	COUNT (N)	PERCENT (%)
GENDER		
FEMALE	45	98
MALE	1	2
RACE/ETHNICITY		
WHITE	5	11
BLACK	30	65
HISPANIC	9	20
OTHER RACE/ETHNICITY (ASIAN, MULTI-RACIAL, OTHER)	2	4
GRADE LEVEL		
6 GRADE	17	37
7 GRADE	14	30
8 GRADE	15	33
ENGLISH LANGUAGE		
ENGLISH ONLY	32	70
SPEAKS ENGLISH AND ANOTHER LANGUAGE AT HOME *	14	30

Note:
Total N = 46 across four urban middle schools.
* Other languages included Spanish, Somalian, Amharic, Urdu, Bengali, Tigrinya (east African language), Haitian Creole, Farsi, and Hausa.

Figure 1: BRIGHT-CS Conceptual Model

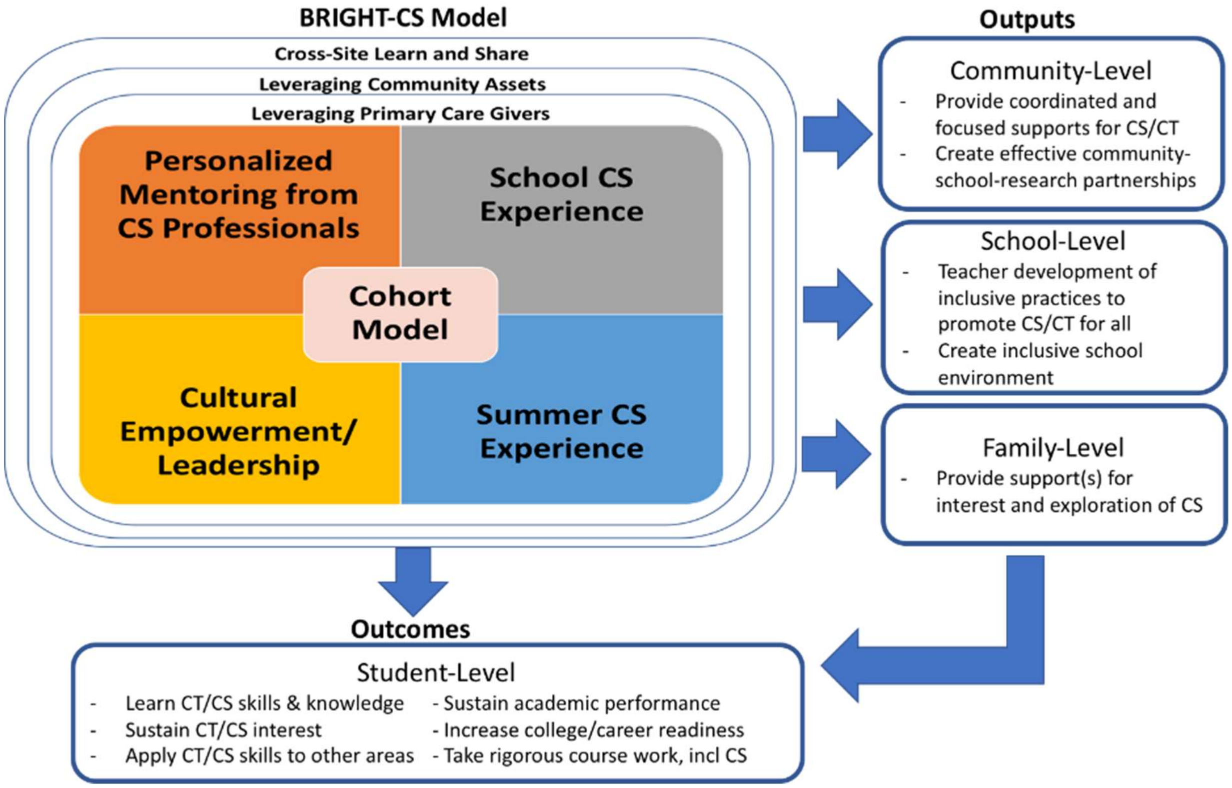
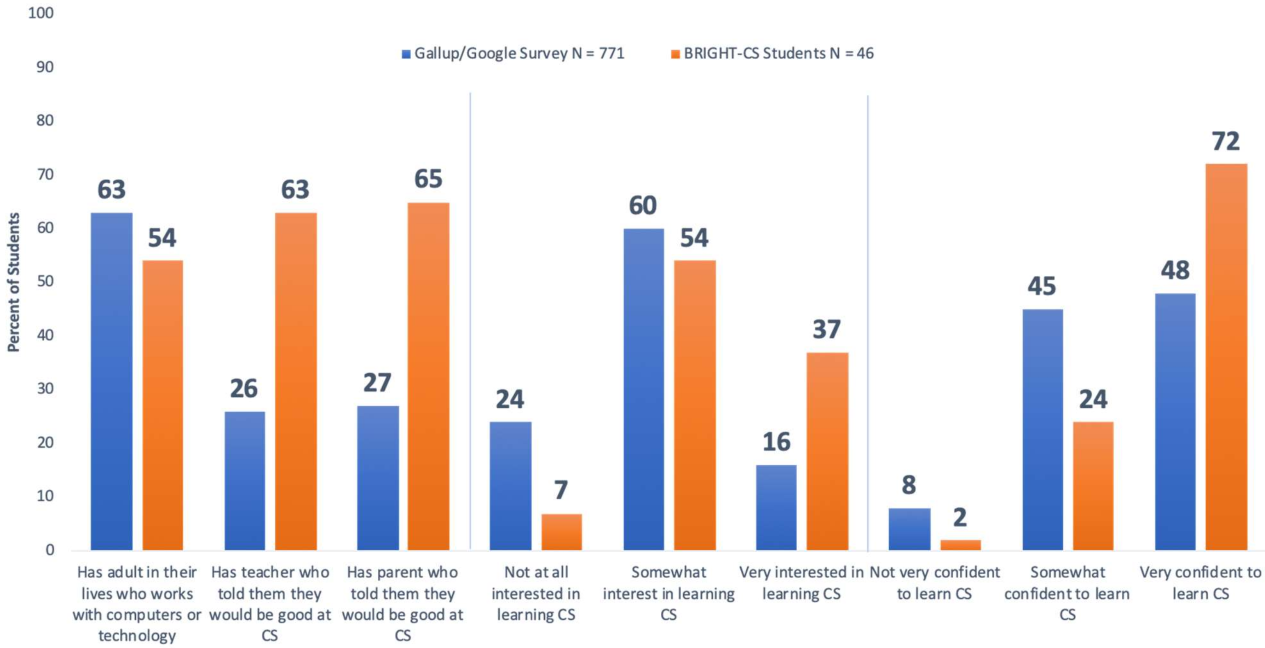


Figure 2: Experience Working with Computers, Benchmark Sample and BRIGHT-CS Students



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