Broadening Participation in Computing: Examining Experiences of Girls of Color

Allison Scott
Kapor Center
2148 Broadway
Oakland, CA 94612
1-415-946-3057
Allison@kaporcenter.org

Alexis Martin
Kapor Center
2148 Broadway
Oakland, CA 94612
1-415-946-3057
Alexis@kaporcenter.org

Frieda McAlear
Kapor Center
2148 Broadway
Oakland, CA 94612
1-415-946-3057
Friedam@kaporcenter.org

Sonia Koshy
Kapor Center
2148 Broadway
Oakland, CA 94612
1-415-946-3057
Sonia@kaporcenter.org

ABSTRACT

In order to enhance participation in computer science for girls of color, this study examines the outcomes of a rigorous out-of-school culturally relevant computer science intervention designed to engage underrepresented students in computing. Findings demonstrated that within-race gender differences exist in early interest in computing. Female students of color demonstrated significantly lower engagement and interest in computing, suggesting that being a member of a marginalized gender group plays a unique role and has a multiplying (negative) effect. Further, there were still significant gender differences in computing engagement after participation in one summer of the computer science intervention. Promising outcomes were revealed among a group of students who chose to enroll in the optional Advanced Placement CS A preparatory course; there were no gender differences in enrollment and completion of the course. In examining longitudinal outcomes, gender is a significant predictor of majoring in computer science in college, with male students much more likely to major in computer science than female students. These findings have important implications for addressing the gender gap in computing, including understanding how the intersection of race and gender presents unique barriers and challenges for women of color in computing, and that interventions to broaden participation in computing must address the unique experiences of women of color.

Keywords

Computing; Culturally Relevant; Disparities; Efficacy; High School; Intersectionality; Underrepresented

1 INTRODUCTION

Addressing disparities in the participation of women and girls in computing and technology remains an economic imperative for countries across the globe [9,19]. Given the increasing demand for highly skilled technology workers to contribute to economic growth and development among both OECD countries and non-OECD countries with emerging economies [19], the lack of participation of women and girls represents a loss of potential talent. Women comprise just 25% of the global computing workforce and roughly 30% of the computing workforce in Europe [6]. Rates of participation in computing among women in computing has been as low as 10% in some countries [9]. On average, gender disparities in computing are considerably wider in countries without substantive technology infrastructure, however sizeable gender disparities also exist in countries with high technology adoption rates [11]. In the United States, which has the largest technology market in the world, women comprise just 25% of the technology and computing workforce [2]. Therefore, parity of representation of women in the global computing workforce could drive economic growth in industrializing countries while satisfying demand for computing workers in the technology sector and spurring innovation in the expanding number of global labor market sectors which depend upon computing skills.

While global participation rates are low for all women in computing, women of non-European descent tend to be even more underrepresented in the global technology workforce than their peers of European descent. Using the United States as an example, women from racial/ethnic groups underrepresented in computing and technology (African American, Latinx, Native American, Native Hawaiian, and Pacific Islander) comprise 20% of the general population and just 4% of the computing workforce [23]. Further, they account for 39% of the female population and only 26% of the Bachelor's degrees awarded to women in computer science [1]. While data sources are difficult to obtain and standardize across contexts [12], research suggests that women of color in nearly all national contexts face a number of specific cultural, psychological and economic barriers to technology access, education, and career opportunities at the intersection of race and gender (18, 19). Examining the barriers, experiences, and outcomes of women of color in computing in the largest technology markets may inform programming for women and girls in other regions and countries, and provide evidence and opportunities to address disparities in the participation of all women in computing across contexts. This research builds upon existing research about the double-bind facing women of color in STEM fields [18], by examining gender differences in computing interest, participation, and outcomes among a sample of underrepresented high school students in the United States.

ITiCSE'17, July 3–5, 2017, Bologna, Italy.
© 2017 ACM. ISBN 978-1-4503-4704-4/17/07...$15.00.
DOI: http://dx.doi.org/10.1145//3059009.3059054

2 THEORETICAL FRAMEWORK

In order to examine gender differences in the experiences and outcomes within computer science, this research draws upon theories of intersectionality and critical race theory. Crenshaw's theory of intersectionality (1991) posits that individuals have multiple identities, and that individuals already marginalized by their racial/ethnic identities may be further marginalized by their other identities, including gender, sexual orientation, socioeconomic status, and (dis)ability. These identities are experienced collectively and are inseparable from one another [8]. Thus, for women of color in computing, it follows that there are unique barriers resulting from the intersection of race and gender, which differ from the barriers experienced by individuals with just one of those marginalized identities [18]. Critical race theory has been used to conceptualize racial disparities in educational contexts as a function of structural and institutional racism manifested in schools and society [14]. In the computing education pipeline, structural disparities detrimentally affecting students of color can be seen in a lack of access to school funding and resources [7], computer science courses [5,16], and access to relevant and engaging curriculum [10]. Additional social and psychological barriers emerge as a reaction to being from a marginalized group [15], affecting students of color and women in computing. These barriers include stereotypes about ability [21], a lack of diverse role models [22], stereotype threat and disidentification within a domain associated with being a member of a marginalized group [21], and stereotypical cues within computer science environments [3]. While these barriers affect students of color and women, it follows that women of color face unique barriers as a result of having dual marginalized identities.

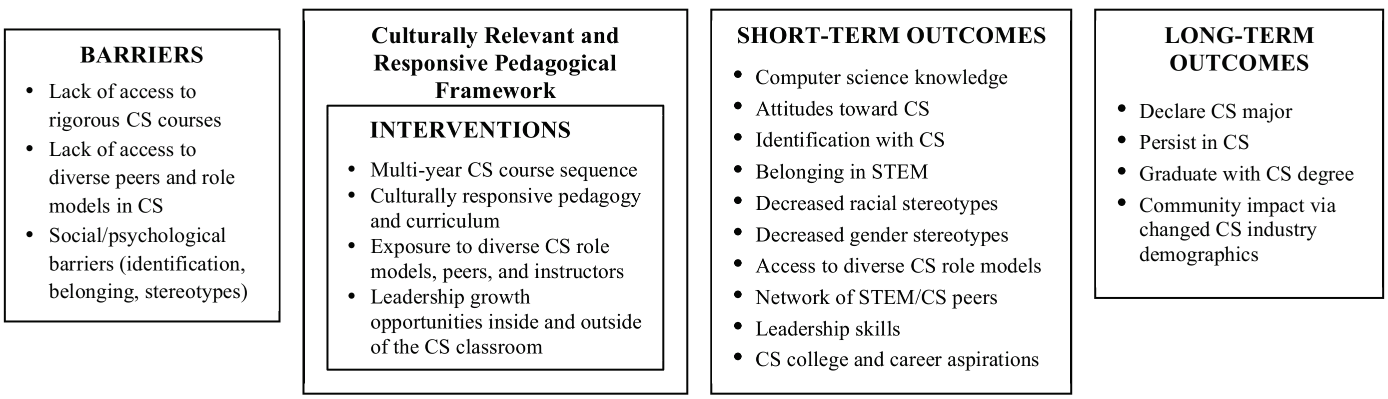

Figure 1: Conceptual Model for STEM Program CS Initiatives

This research will build upon the theoretical frameworks of intersectionality and critical race theory to further explore whether there are unique barriers faced by women of color that affect their interest, participation, and persistence in computer science. This research will go beyond examinations of experiences of girls of color [20], and look comparatively at experiences and outcomes of both gender groups to further explore the double-bind facing women and girls of color in computing. Given the underrepresentation of women in computing across the globe, this research can contribute to understanding of unique experiences of women of color and has implications for informing interventions to increase participation of women of color in computing.

3 METHODOLOGY

3.1 Research Questions

To examine whether there is evidence of a double-bind affecting the outcomes of women of color in computing, this study explores the following research questions: (1) Among underrepresented high school students participating in a rigorous summer intervention program, do gender differences exist in computer science interest and aspirations? and (2) Do existing gender differences persist in participation in AP CS A courses in high school and the pursuit and completion of computer science degrees?

3.2 Program Context

This study took place within a 5-week, 3-summer science, technology, engineering and mathematics (STEM) program serving underrepresented high school students across four sites in Northern and Southern California. Students are admitted to the program in the summer between 9th and 10th grade, and attend for three consecutive summers. The academic programming includes: math, science, and computer science core courses, an engineering design course, and college preparation activities in addition to a youth development-focused residential program with lessons and activities related to social, emotional, and leadership development. This research specifically examines the impact of the computer science intervention components on student outcomes. The computer science intervention includes a three-sequence computer science course, taken by all students, with curriculum adapted from Exploring Computer Science (CS1), Beauty and Joy of Computing (CS2), and AP Computer Science A (CS3; College Board, 2016; UC Berkeley and Education Development Center, 2012; GSEIS, Center X, 2004). Each course provides 37.5 total hours of instruction per summer, for a total of 112.5 hours. Students have the option of participating in an additional AP CS preparatory course during their senior year which prepares students to take the AP CS A exam. All of the computer science programming and activities are situated within a culturally relevant and responsive pedagogical framework and provide exposure to diverse computer science role models, diverse instructors, and support networks of diverse peers (Figure 1).

3.3 Participants

Three samples were included in this study: (1) a sample of current high school students who participated in the program during the summer of 2016, (2) a sample of participants in 2014 and 2015 who enrolled in the optional AP CS A preparatory course, and (3) a sample of current college students who previously participated in the program in 2014 and 2015. In Sample 1, participants were recruited for this research study through a verbal invitation given during the program orientation meeting attended by students and their parents. A total of n=205 students consented to participate in the research study and completed both the pre and post-survey (80% participation rate). All participants were members of racial/ethnic groups underrepresented in STEM fields, relative to their percentage of the United States population. The majority of participants were Hispanic/Latinx (52%), Black/African American (34%) and Southeast Asian (8%), with participants classified as "other" or "multiracial" comprising the remaining 6%. The sample consisted of slightly more females (53%) than males (47%). Tenth graders were 43% of the sample, with 11th and 12th graders comprising 30% and 27%, respectively. The majority of students came from low-income households, as determined by federal qualification for Free/Reduced Price Lunch (78%). Seventy-six percent of the students will be the first in their family to complete college. All students attended high schools in California, in the San Francisco Bay Area and Los Angeles Area; with 92% attending public schools.

In Sample 2 and Sample 3, demographic data and program participation data were collected from program records of participants from 2014 and 2015. A total of 183 students participated in the program during that time, and of those participants, 71 (39%) chose to enroll in the optional AP CS A preparatory course during their senior academic year. 58% were male and 42% were female; 28% were African American and 62% were Latinx, with the remaining 10% from other underrepresented backgrounds. In Sample 3, students who had previously participated in the program were contacted by email and invited to complete a follow-up survey. A total of 129 students who participated in 2014 and 2015 completed the survey. In addition, educational data of 6 students from the 2014 and 2015 cohorts were captured from their recently updated LinkedIn profiles for an aggregated total of 135. Eighty-seven percent of those were enrolled in four-year universities (n=117). Forty-nine percent of the participants were male, and 51% female.

3.4 Data Collection Instruments, Procedures, and Analysis

Survey instruments, reviews of program records, and focus groups were used to examine computer science engagement and participation by gender. A pre- and post-program online survey containing demographic questions and 9 scales including a computer science engagement scale, was administered to all participants in Sample 1. The computer science engagement scale was the only scale utilized within this study and consisted of 6 items (α=.90) assessing interest in computer science and interest in pursuing computer science as a major in college and as a career. Items included, "I think computer science is interesting," and "I am likely to major in computer science in college." All items were measured on a 5-point Likert scale with higher values indicative of higher levels of agreement. Advanced Placement CS A course enrollment and participation of students within Sample 2 was assessed using program records of student enrollment, participation, and completion of the AP CS A preparatory course in 2014-15 and 2015-16.

An alumni survey was used to collect demographic data and student current major/field of study (in addition to other variables not analyzed in this study) with Sample 3 participants in the fall of 2016. Current enrollment in a computing major was measured with one open-ended item asking students to "indicate your current undergraduate major." Responses that included computer science, computer engineering, computer programming, and electrical engineering were coded as computing majors. To collect qualitative data on experiences with computer science in the program, two focus groups were held during the summer of 2016 with 11 female and 6 male students. For the purposes of this study, only the female responses were utilized. A focus group protocol consisting of nine questions focusing on engagement, learning, and interest, was utilized, including items such as "How, if at all, did your [program name] computer science class affect how you feel about computer science?" and "What have you learned in computer science that really stands out to you?"

Descriptive analyses were used to examine the frequency of student participation, course completion, and test-taking rates, by gender. Descriptive analyses were also used to examine post-secondary outcomes by gender. Independent-samples t-tests and regression analyses were used to examine whether male and female participants differed significantly in CS engagement and whether gender was a significant predictor of post-program CS engagement levels, AP CS A participation, and college CS major. Focus group notes and transcripts were analyzed utilizing qualitative analysis software, and qualitative and quantitative data were triangulated to synthesize findings.

4 FINDINGS

4.1 Computer Science Interest and Engagement by Gender

Prior to entering the program, male students had significantly higher levels of engagement than female participants (M_{DIFF} = 0.33, 95% CI [0.13, 0.54], $t(203) = 3.183$, $p = .002$.), demonstrating initial gender differences even among racially underrepresented populations (M_M=3.82, SD=.66 vs M_F=3.49, SD=.83). Computer science engagement from pre- to post-program was then analyzed to determine whether the intervention resulted in significant increases in computer science engagement. While there were no significant increases in CS engagement from pre- to post-program overall, $t(200) = -.68$, p = n.s (M_{PRE}=3.66, SD=.76 to M_{POST}=3.69, SD=.86), regression analyses showed several demographics, including gender to be a significant predictor of post-program CS engagement scores. This finding revealed female participants were less likely to be engaged in CS than male participants ($\beta = -.33$, $p<.001$). Qualitative data from surveys confirmed quantitative findings that disparities by gender exist in student perceptions of their "favorite course." Although girls represent 53% of participants, just 23% listed computer science as their "favorite," compared to 39% of male participants (Figure 2). Of the girls who chose computer science as their favorite course, 21% had just completed their first computer science course in the program. However, 50% of girls who listed computer science as their favorite class were in their second year of the program, suggesting that taking multiple CS courses may increase interest in computer science among girls of color. This indicates two important findings: (1) girls of color started out with less interest in computer science, but this interest grew over time, and (2) the intervention had differential effects on males versus females, with the intervention unable to close the gender gap in interests and aspirations in computer science, even though students received the same intervention and were from otherwise similar demographic backgrounds.

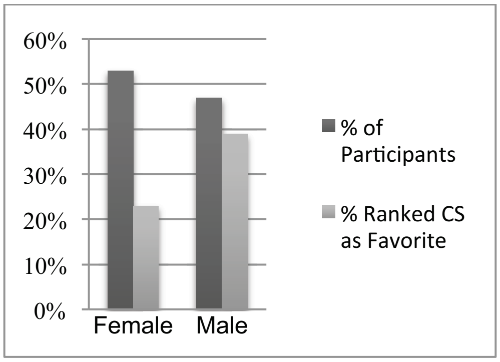

Figure 2. CS As Favorite Course, by Gender

Additional qualitative data from girls who listed computer science as their favorite course revealed promising practices and interventions that could be implemented to address barriers to participation among girls of color. Among girls who were highly engaged in computer science, themes of seeing CS as "fun and interesting" and "challenging" and seeing its relevance to their other interests (e.g. music, video games) were described. They also described the lack of exposure to CS in their high school and how exposure to the program's CS courses made them aware and interested in pursuing CS in college and career. Girls also indicated that teachers played a critical role in making the content engaging and in having high expectations of them.

4.2 Advanced Placement Computer Science Participation and Completion by Gender

To examine whether gender disparities in interest persist, the participation and completion rates in the optional AP Computer Science A preparatory course in 2014 and 2015 were examined. Seventy-one students chose to enroll in the optional course. Of these, 58% were male and 42% were female, demonstrating slight gender differences in enrollment rates. Of those who enrolled in the course, 41 (58%) of participants completed the course. Course completion rates and AP CS A exam completion rates were relatively equal by gender, with 60% of female students completing the course compared to 58% of males, demonstrating no gender disparities in persistence through the course. Regression analyses further reveal gender is not a significant predictor of AP CS A course participation (β = .04, p=ns) or completion (β = .10, p=ns). This is an important finding, demonstrating that of the group of students who self-select into the AP CS A prep course, there are no gender disparities in exam completion, which appears to counter the disparities seen broadly across the nation in AP CS A test-taking by gender [5].

4.3 Post-Secondary Computer Science Outcomes by Gender

This study also aimed to examine longitudinal outcomes and whether gender differences in initial interest in majoring in CS persisted into post-secondary education, among students who participated in the program in 2014 and 2015. Among the 117 program alumni currently attending 4-year colleges/universities, 24% of were declared CS majors. Males comprised the overwhelming majority of the CS majors (79%), while females comprised just 21%. Regression analyses demonstrated that gender is a significant predictor of majoring in CS in college, with female participants less likely to be CS majors than males (β = -.35, p=.00). This finding provides further evidence of the persistence and prevalence of female underrepresentation in the CS in post-secondary education, despite early interventions. Further, participation in the AP CS A course was a significant predictor of majoring in CS for male students (β = -.26, p=.05), but not for female students (β = -.03, p=ns). This is an interesting finding, suggesting that although previous research has demonstrated that participation in advanced computing courses are strong predictors of majoring in computer science in college [16], in this sample, taking a course did not increase the likelihood of majoring in CS for female students, further suggesting unique disparities among young women of color in computing.

5 CONCLUSIONS AND IMPLICATIONS

In computing and technology, there are vast disparities in participation by gender, with women underrepresented in computing worldwide. Within the United States context, where both women and people of color are underrepresented in computing, evidence suggests there are additional barriers affecting women of color who are marginalized by both race and gender [17,18]. Expanding upon this body of theoretical and empirical evidence, this study examined short and long-term outcomes of a sample of underrepresented high school students of color who participated in computing courses, and found that within-race gender differences exist in early interest in computing. Despite having similar racial and socioeconomic backgrounds, female students of color demonstrated significantly lower engagement and interest in computing, suggesting that being a member of a marginalized gender group plays a unique role and has a multiplying (negative) effect. Further, participation in the computing intervention alone did not close the gender gap; there were still significant gender differences in computing engagement after participation in one summer of the CS intervention. Promising findings were revealed among a small and self-selected group of students, who chose to enroll in the optional AP CS A preparatory course; there were no gender differences in enrollment and completion of the AP CS A course. In examining longitudinal outcomes however, gender is a significant predictor of majoring in computer science in college, with male students much more likely to major in computer science than female students. Participation in AP CS A in high school was only a significant predictor of majoring in computing in college for male students, but not female students. These findings have important implications for addressing the gender gap in computing, including understanding how the intersection of race and gender presents unique barriers and challenges for women of color in computing, and that interventions to broaden participation in computing must address the unique experiences of women of color. Interventions that provide short-term engagement and exposure to computer science may not be sufficient to address race and gender barriers to computing. Additional research is needed to understand initial barriers and experiences which affect early engagement and interest in computing for women of color and promising practices that increase and promote engagement in computing throughout high school, and thus increase participation and persistence in computing in college. Research within same-gender and different race context can also provide further evidence about effective intervention strategies. Expanding this body of research will have implications for broadening participation among women in computing in nations across the globe.

ACKNOWLEDGMENTS

This work is supported by the National Science Foundation under Grant Number 1339424.

REFERENCES

[1] Bartels, A. 2016. Global tech market will continue to grow at 4%-5% rates in 2016 and 2017. Retrieved from http://blogs.forrester.com/andrew_bartels/16-01-05-global_tech_market_will_continue_to_grow_at_4_5_rates_in_2016_and_2017
[2] Bureau of Labor Statistics. 2013. Occupational Projections through 2022.
[3] Cheryan, S., Davies, P.G., Plaut, V.C., and Steele, C.M. 2009. Ambient belonging: How stereotypical cues impact gender participation in computer science. *J. Pers and Social Psych*. 97,6, 1045-1060.
[4] Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review.* 43, 6, 1241-1299.
[5] College Board. 2016. Report to the nation.
[6] Economic Commission for Latin America and the Caribbean (ECLAC). 2014. *The software and information technology services industry in the United States: An opportunity for the economic autonomy of women in Latin America*. Santiago, Chile. Retrieved from http://selectusa.commerce.gov/industry-snapshots/software-and-information-technology-services-industry-united-states
[7] EdTrust. 2015. Funding Gaps. Retrieved from https://edtrust.org/wp-content/uploads/2014/09/FundingGaps2015_TheEducationTrust1.pdf
[8] Essed, P. 2001. Understanding everyday racism: An interdisciplinary theory. Sage Publications.
[9] Galpin, V. 2002. Women in computing around the world. *SIGSCE Bulletin*. 34, 2, 94-100.
[10] Goode, J. and Margolis, J. 2011. Exploring computer science: A case study of school reform. *ACM Trans on Comput Educ.* 11, 2.
[11] Hafkin, N. J., and Huyer, S. 2007. Women and gender in ICT statistics and indicators for development. *Information Technologies and International Development*. 4,2, 25–41. http://doi.org/10.1162/itid.2008.00006
[12] Hilbert, M. 2011. Digital gender divide or technologically empowered women in developing countries? A typical case of lies, damned lies, and statistics. *Women's Studies Intl Forum*. 34, 6, 479–489. http://doi.org/10.1016/j.wsif.2011.07.001
[13] Huyer, S. 2015. Is the gender gap narrowing in science and engineering? *UNESCO Global Science Report: Towards 2030*. Retrieved from http://unesdoc.unesco.org/images/0023/002354/235406e.pdf%5Cn
[14] Ladson-Billings, G., and Tate, W. F. 1995. Toward a critical race theory of education. *Teachers College Record.* 97,1, 47-67.
[15] Major, B., and O'Brien, L.T. 2005. The social psychology of stigma, *Ann Rev of Psych.* 56, 393-421.
[16] Martin, A., McAlear, F. and Scott, A. 2015. Path not found: Disparities in access to computer science courses in California high schools. Retrieved from: www.lpfi.org/pnf
[17] National Science Foundation. 2015. Survey of graduate students and postdoctorates in science and engineering. Retrieved from: https://www.nsf.gov/statistics/2015/nsf15311/tables/pdf/tab3-1-updated-2016-06.pdf
[18] Ong, M., Wright, C., Espinosa, L.L., and Orfield, G. 2011. Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in Science, Technology, Engineering, and Mathematics. *Harvard Educ Review*. 81,2, 172-208.
[19] Powell, C., and Chang, A. M. 2016. *Women in Tech as a Driver for Growth in Emerging Economies*. Council on Foreign Relations.
[20] Scott, A, Martin, A., and McAlear, F. 2016. Computer science in California's schools: 2016 AP CS results and implications. Retrieved from: http://access-ca.org/wp-content/uploads/sites/4/2017/01/KC16017_Report-Final.pdf
[21] Steele, C. M., and Aronson, J. 1995. Stereotype threat and the intellectual test performance of African Americans. *J. Pers. and Social Psych.* 69,5, 797–811.
[22] Stout, J. G., Dasgupta, N., Hunsinger, M., and McManus, M. 2011. STEMing the tide: Using ingroup experts to inoculate women's self-concept and professional goals in science, technology, engineering, and mathematics (STEM). *J. Pers. and Social Psych.* 100, 255–270.
[23] U.S. Census Bureau, Population Division. 2015. *Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the United States.*