Moving Students of Color from Consumers to Producers of Technology

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A volume in the Advances in Educational Marketing, Administration, and Leadership (AEMAL) Book Series

IGI GLOBAL
DISSEMINATOR OF KNOWLEDGE
www.igi-global.com

Published in the United States of America by
IGI Global
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Yolanda Rankin and Jakita Thomas, editors.
Description: Hershey, PA : Information Science Reference, [2017] | Includes bibliographical references.
Identifiers: LCCN 2016050992| ISBN 9781522520054 (hardcover) | ISBN 9781522520061 (ebook)
Subjects: LCSH: Computer literacy--United States. | Digital divide--United States. | Minorities in technology--Government policy--United States. | Minorities in engineering--Government policy--United States. | Multiculturalism--United States. | Multicultural education--United States. | Technical education--United States.
Classification: LCC QA76.9.C64 M68 2017 | DDC 004--dc23 LC record available at https://lccn.loc.gov/2016050992

This book is published in the IGI Global book series Advances in Educational Marketing, Administration, and Leadership (AEMAL) (ISSN: 2326-9022; eISSN: 2326-9030)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Chapter 4

Enhancing Participation in Computer Science among Girls of Color:

An Examination of a Preparatory AP Computer Science Intervention

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ABSTRACT

To address disparities in computing among girls of color, this chapter examines the impact of a multi-year, out-of-school computer science intervention with n=108 female high school students of color. This rigorous and comprehensive 5-week computer science intervention designed within a culturally-relevant framework, demonstrated the following outcomes: 1) one exposure to the intervention demonstrated a significant impact on computer science knowledge, attitudes, and access to diverse peers/role models, 2) the impact of the intervention endured after a 9-month period, and 3) repeated-exposure to the intervention (2 sequential 5-week interventions) produced greater growth than just one summer. These findings suggest that short-term interventions can be impactful, and repeated exposure opportunities are

DOI: 10.4018/978-1-5225-2005-4.ch004

needed to increase growth in knowledge, attitudes, and aspirations among girls of color in computing. This research provides preliminary data for a model for effective programming for girls of color in computer science and has implications for practitioners, researchers, and policymakers.

INTRODUCTION

Current data indicate that women comprise just 25% of the computing workforce, while African Americans and Latinos combined comprise just 15% (Bureau of Labor Statistics, 2015). By comparison, women comprise 50% of the U.S. population, and African American and Latinos combined make up 30% of the nation's population (U.S. Census Bureau, 2014). The underrepresentation of women, African Americans, and Latinos in the computing workforce is of significant concern for numerous reasons, including the future projected job growth in computing fields, the lack of supply of computing professionals to keep pace with the demand, and the demonstrated increased success and innovation associated with diverse teams (Carneval, Smith & Melton, 2011; Hunt, Layton & Prince, 2015; U.S. Census Bureau, 2014). Thus the continued underrepresentation of women, African Americans, and Latinos in computing has the potential to not only affect the continued economic success of the technology industry, but also has implications for creating innovative technological solutions to address problems affecting all segments of society.

Barriers to Computing Among Women of Color

In examining the computing pipeline, from K-12 education into the workforce, there are clear disparities in participation across the pipeline. At the high school level, females make up just 22% of all students taking the Advanced Placement (AP) Computer Science exam, while African Americans and Latinos participate in AP Computer Science at even lower rates (13% combined; College Board, 2015). In post-secondary education, women comprise just 19% of all computer science Bachelor's degree earners, with African Americans and Latinos also comprising a small percentage of students earning degrees in computer science (11% and 9%, respectively; NSF, 2015). It is also critically important to examine the outcomes of women of color as a unique population which is often overlooked in discussions of race and gender in computing. A growing body of literature discusses the "double-bind" facing women of color in STEM and the ways in which dual marginalized identities affect educational experiences in STEM fields (Ong, Wright, Espinosa & Orfield, 2011; Perna et al., 2009). Statistics reveal significant within-gender and within-race disparities affecting women of color in computer science. For example, 70% of all African American and 81% of Latino computer science degree earners are male (NSF, 2015). Within-gender disparities also exist: the vast majority of women who earn Bachelor's degrees in computer science are White and Asian (55%) and just 17% are African American and 9% Latina (NSF, 2015). The disparate outcomes for women of color in computing can be linked to barriers in access to computer science courses, lack of engaging and relevant curriculum, and social/psychological barriers affecting attitudes towards computer science.

Research indicates that women of color face both structural and social/psychological barriers to pursuing and persisting in computer science. At the high school level, girls of color lack access to advanced computer science courses, where schools serving high numbers of underrepresented students of color are much less likely to offer rigorous computer science courses than schools serving predominately White or Asian students (Margolis, Goode, Holme, & Nao, 2008; Martin & Scott, 2015). Without access to Advanced Placement computer science courses, students are eight times less likely to pursue computer science studies in higher education (Mattern, Shaw & Ewing, 2011). Even with access to computer science coursework, a major challenge in the Advanced Placement computer science courses is making the content engaging, interesting, and relevant, especially when attempting to engage students of color (Goode, 2010; Goode & Margolis, 2011). Further, students of color are often discouraged or disinterested in studying computer science due to misconceptions about computer science as a discipline and career path (Badagliacco, 1990; Carter, 2006; Margolis, Goode & Bernier, 2011), perceptions of computer science as lacking interpersonal or social relevance (Peckham et al., 2007; Rich, Perry & Guzdial, 2004; Williams et al., 2007), a lack of diverse role models (Anderson et al., 2008; Cain, 2012; Goode, 2008; Zimmerman et al., 2011), isolation and lack of a peer support network (Moses, 1993), stereotype threat associated with being a member of a marginalized group in STEM (Steele & Aronson, 1995), and the presence of stereotypical cues within computer science environments (Cheryan, Davies, Plaut & Steele, 2009; Cheryan, Meltzoff, & Kim, 2011).

Promising Initiatives and Interventions to Enhance Participation in Computing

In response to significant disparities affecting the participation of individuals from underrepresented groups in computer science, numerous non-profit organizations, philanthropic foundations, government entities, technology industry leaders, and for-profit companies have begun developing and implementing a variety of computer science initiatives across the nation and within specific states and cities. These initiatives include: government grant programs (e.g, NSF, OSTP, 2015), citywide initiatives (e.g, Oakland CS for All, CSForAll in NYC), hackathons, coding bootcamps, summer programs, computer science curriculum development and implementation (e.g., Exploring Computer Science, Computer Science Principles), teacher professional development (e.g., Code.org), massive online open courses, tech internships and career development, and state-level legislation and policy to increase access to computer science in public schools (e.g., Alliance for California Computing Education for Students and Schools).

While these promising initiatives and investments in broadening participation in computer science have the opportunity to increase engagement and participation among underrepresented students, research on the effectiveness of these interventions is still emerging. Research has documented effective pre-college STEM intervention programs, strategies for engaging underrepresented groups (Maton, Hrabowski & Schmidt, 2000; Scott & Martin, 2014; Valla & Williams, 2012), the efficacy of the Exploring Computer Science curriculum and advocacy to increase access among underrepresented groups (Goode & Margolis, 2011), and out-of-school computing interventions (Scott, Sheridan & Clark, 2014). Yet, additional research is needed to examine computing interventions, especially in out-of-school contexts, and approaches for engaging women of color in computing. Additionally, little research has been done to document approaches to preparing students for Advanced Placement Computer Science coursework. Further research is warranted to understand:

1. The efficacy of computing interventions with girls of color,
2. The impact of specific intervention components and culturally relevant intervention frameworks, and
3. The level/intensity of intervention needed to produce significant outcomes in knowledge, attitudes, and aspirations.

Thus, this chapter examines the impact of a computer science intervention on the computer science knowledge, attitudes, and aspirations of high school girls of color. This chapter examines the impact of short-term exposure (one summer) and repeated-exposure (two summers) to understand dosage effects in computer science interventions and will provide data to support a replicable model for enhancing participation in computer science among girls of color and underrepresented students more broadly.

Research Questions

1. To what extent does this computer science intervention impact computer science knowledge, attitudes, and college and career aspirations among girls of color?

2. Does this intervention impact the exposure to diverse role models and peers, endorsement of negative racial and gender stereotypes about STEM ability, identification with computer science, and leadership skills among girls of color?
3. To what extent does the intervention have lasting effects on girls of color and do the intervention effects persist after one year? What is the impact of a second summer of exposure on the computer science intervention?

BACKGROUND

Effective STEM Interventions for Underrepresented Populations

Given the aforementioned underrepresentation among girls of color in computer science, pre-college intervention programs have the potential to broaden participation among this population. Two review articles synthesized ten effective features of successful K-12 STEM intervention programs for underrepresented groups, which include:

1. Supportive peer networks and adult mentors,
2. Rigorous coursework,
3. Incorporation of students' cultural background into program content and structure,
4. Interventions spanning multiple years,
5. College admissions and financial aid assistance,
6. Sensitivity to participants' cultural backgrounds,
7. Maintaining interest and positive views of STEM,
8. Hands-on experiences with role models,
9. Field trips to STEM-related industries, and
10. Parental involvement (Gandara & Bial, 2001; Valla & Williams, 2012).

In computer science, interventions have typically included culturally relevant curriculum and increased access to computer science courses (Goode & Margolis, 2011; Margolis et al., 2008). Less is known empirically, however, about effective computer science interventions which address the specific experiences of girls of color. Research is needed to both examine the effectiveness of interventions and to propose intervention models for replication.

Culturally Responsive Computing

Culturally responsive pedagogical frameworks utilize the cultural characteristics and experiences of ethnically diverse students to teach more effectively, while developing critical perspectives to challenge institutional inequities (Gay, 2000; Ladson-Billings, 1995). Culturally responsive pedagogical practices have become increasingly recognized as effective in engaging diverse learners in STEM subjects (Jett, 2013; Scott & Martin, 2014). Building upon these frameworks, culturally responsive computing (CRC; Scott, Sheridan & Clark, 2014) is an approach to devising computer science education that aims to:

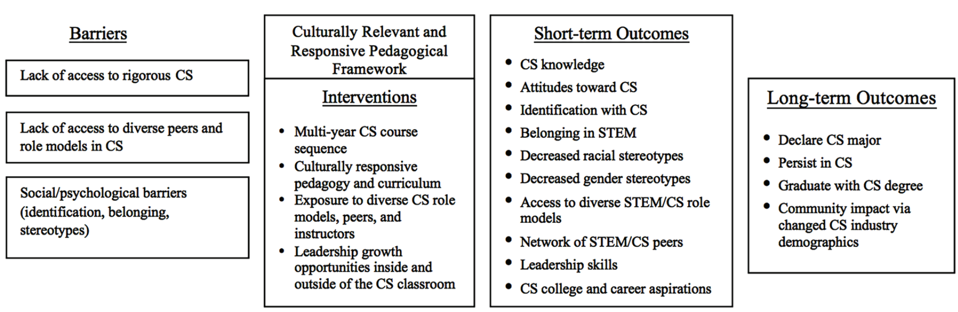
1. Motivate students and improve STEM learning experiences,
2. Provide a deeper understanding of heritage and vernacular culture, empowerment for social critique, and appreciation for cultural diversity,
3. Diminish the separation between the worlds of culture and STEM,
4. Use technology to not only respond to identity issues, but also to satisfy pedagogical demands of the curriculum (Eglash, Gilbert, Taylor, & Geier, 2013).

Specifically, CRC is designed as a framework to address digital disparities by considering intersectionality, innovation, and community advancement (Scott, Sheridan & Clark, 2014) and is a useful framework to examine and address experiences and interventions for girls of color in computer science.

Conceptual Framework

Figure 1 summarizes the conceptual framework guiding the development of the computer science program aiming to address barriers specific to girls of color in

Figure 1. Conceptual framework



CS through research-based interventions (e.g., computer science courses) within a culturally relevant framework. This research study examines the impact of the intervention on the short-term outcomes of high school girls of color.

OUTCOMES OF AN AP COMPUTER SCIENCE PREPARATORY INTERVENTION FOR GIRLS OF COLOR

Program Context and Intervention Summary

This study examines a computer science intervention within a 5-week, 3-summer STEM program serving underrepresented high school students (50% female) on four college campuses in California. The STEM summer program serves rising 10th, 11th, and 12th grade students and the programming includes: Math, Science, and Computer Science core courses, electives courses, college preparation activities, and a residential (on-campus) experience for students, which includes lessons and activities within a youth development framework.

The 5-week course sequence is part of a 3-summer course sequence and senior year academic component which prepare students to take the AP Computer Science exams by their senior year in high school. The computer science intervention assessed in this study includes a 5-week computer science course, with curriculum adapted from Exploring Computer Science (CS1; 10th grade), Beauty and Joy of Computing (CS2; 11th grade), and AP Computer Science A (CS3; 12th grade; University of California, Berkeley and Education Development Center, 2012; University of California, Los Angeles, Graduate School of Education and Information Studies, Center X, 2004). Topics in the course include: developing the foundational problem solving and computational skills and using Scratch (CS1), three of the "seven big ideas," including the importance of data in computing, the Snap! programming language and the societal impact of computing (CS2), and introductory Java and HTML programming (CS3 and AP CS A prep). Each course provides 37.5 total hours of instruction per summer, for a total of 112.5 hours. After completion of CS3, students can take the final course, an AP Computer Science preparation course during the academic school year, which is presented in a blended format using a combination of online and in-person instruction. The intervention activities are situated within a culturally relevant and responsive pedagogical framework and provide exposure to computer science role models, diverse instructors and networks of diverse peers, as well as community-building and leadership development activities (Figure 1).

Participants

Study 1

One hundred and eight female high school students participating in the 5-week summer STEM program comprised the sample of this study. All participants were members of racial groups underrepresented in STEM: Latino (55%), African American (30%), Filipino (8%), Other Southeast Asian and Multiracial (17%). The sample contained 10th (37%), 11th (45%), and 12th graders (18%). Eighty-four percent of students were Free/Reduced Priced Lunch-eligible and 82% will be the first in their family to complete a college degree. Ninety-four percent of students attended public or charter schools.

Study 2

Seventy-six of the original 108 female high school students participating in the second year of the multi-year 5-week summer math and science program comprised the sample within study 2. The remaining 32 students in study 1 did not participate in two summers of the program, and thus were excluded from analysis in study 2. In study 2, all participants were members of racial groups underrepresented in STEM fields, including 26% African American, 63% Latino, 8% Filipino, and 2% Other Southeast East Asian and Multiracial. Given that this sample included students participating in their second year of the program, the sample includes 11th graders (35%) and 12th graders (64%). Ninety percent of the students in sample 2 were Free/Reduced Priced Lunch Eligible, and 86% will be the first in their family to complete a college degree. Ninety-five percent of students attended public or charter schools.

Study Instruments

The study instruments consisted of:

1. A computer science concept inventory, and
2. A comprehensive online survey containing the nine attitudes, aspirations, and experiences scales utilized within this study.

The computer science concept inventory was developed in consultation with the program's computer science curriculum developers to assess five core components of the computer science curriculum. The attitudes, aspirations, and experiences survey was developed in consultation with existing research literature and utilized previously-tested scales and items (Scott & Martin, 2014; Scott & Martin, 2013).

Cronbach's alpha was used to assess the reliability of each scale and to examine the performance of each item within the scale.

Computer Science Concept Inventory

The self-reported concept inventory assessed 4 core components of the computer science curriculum including the ability to use variables and broadcast blocks in Scratch, familiarity with using HTML and CSS, and knowledge of programming languages including Java (α=.78; 4 items). Sample questions included: "How much knowledge do you have about programming in Java?" and "How much knowledge do you have about using variables and blocks in Scratch?" All items were measured on a 5-point Likert scale with higher values indicative of greater self-reported knowledge of each of the concepts.

Attitudes, Aspirations, and Experiences Survey

The attitudes, aspirations, and experiences survey contained eight scales including:

1. Attitudes towards computer science,
2. Identification with computer science,
3. Computer science aspirations,
4. Access to diverse role models,
5. Access to networks of STEM peers,
6. Leadership skills,
7. Endorsement of negative racial stereotypes about STEM ability, and
8. Endorsement of negative gender stereotypes about STEM ability.

Attitudes towards Computer Science

The Attitudes towards CS scale (α=.88) consisted of 3 items assessing the extent to which students perceive of computer science as interesting, stimulating and enjoyable. Sample questions included: "I think computer science is interesting," and "Do you think computer science is fun or boring?" All items were measured on a 5-point Likert scale, with higher values indicative of more positive attitudes towards computer science.

Identification with Computer Science

The Identification with CS scale (α=.68) consisted of 2 items assessing students' perceptions of computer science as relevant to themselves, their community, and their everyday lives. Sample questions included: "I see examples of how computer science applies to my everyday life," and "Computer science can be used to solve problems facing my community." All items were measured on a 5-point Likert scale, with higher values indicative of greater perceptions of identification with and relevance of computer science.

Computer Science Aspirations

The Computer Science aspirations scale (α=.81) consisted of 3 items assessing students' interest in pursuing computer science in college and career. Sample questions include: "I want to continue learning new computer science skills" and "I am likely to major in computer science in college." All items were scored on a 5-point Likert scale, with higher values indicative of stronger computer science aspirations.

Access to Diverse Role Models

The Access to Diverse Role Models scale (α=.81) consisted of 2 items assessing students' self-reported access to role models from diverse racial and gender backgrounds in the field of Computer Science. Sample questions included: "I have role models in computer science who are people of color," and, "I have role models in computer science who are women." All items were scored on a 5-point Likert scale, with higher values indicative of increased access to diverse role models.

Network of STEM Peers

The Network of STEM Peers scale (α=.84), consisted of 3 items assessing the extent to which students feel a part of a supportive community of same-race/gender peers with similar interests. Sample questions included: "I know a lot of students like me who are interested in computer science," and "I feel like I am part of a community of students who are interested in computer science." All items were scored on a 5-point Likert scale, with higher values indicative of greater perceptions of belonging within a community of same-race/gender peers.

Leadership Skills

The Leadership Skills scale (α=.86) consisted of 3 items assessing students' self-reported confidence in leadership roles and perceptions of leadership skills. Sample questions asked included: "I feel comfortable leading planning and decision-making when working with my peers" and "I believe that my leadership skills are [weak/

strong].” All items were scored on a 5-point Likert scale, with higher values indicative of greater self-reported leadership skills.

STEM Racial and Gender Stereotypes Scales

The STEM Racial Stereotypes scale (α=.82) and the STEM Gender Stereotypes scale (α=.89) each consisted of 3 items assessing the extent to which students explicitly endorse negative stereotypes about African Americans and Latinos (Racial Stereotypes) and women (Gender Stereotypes) within science and mathematics. These items were developed in consultation with literature on measurement of beliefs about academic abilities and stereotypes within the sciences (Rowley et al., 2007; Smith & Krajkovich, 1979). Sample questions included: “African Americans and Latinos are less capable of success in STEM than Whites and Asians (reverse-coded)” and “Men have stronger math and science abilities than women (reverse-coded).” All items were measured on a 5-point Likert scale, with higher values indicative of less explicit endorsement of negative stereotypes.

Data Collection Procedures and Analysis

Study 1

Within a repeated-measures design, quantitative data were collected from 108 participants at two different intervals, pre- and post-intervention (study 1). All participants were administered a pre-program survey and concept inventory and an identical post-program survey and concept inventory at the completion of the program. Paired-samples T-tests were run to determine whether mean scale values for computer science knowledge, attitudes, aspirations, racial and gender stereotypes, identification, and leadership skills changed significantly from pre- to post-intervention.

Study 2

A second round of data were then collected from 76 of the original 108 students in study 1. In study 2, all participants were administered a pre- and post-program survey in 2013, and another pre- and post-program survey covering the same set of variables in 2014 (Table 1). Paired-samples T-tests were run to determine whether intervention effects persisted or changed significantly from post-intervention (T2) to one year beyond the intervention (T3). Finally, paired-samples T-tests were run to determine: (a) growth in mean values for each variable over two summers (T1-

Table 1. Research design and data collection

	# of participants	Data Collection Intervals				Data Collection Instruments
		T1 (Pre)	T2 (Post)	T3 (Pre)	T4 (Post)	
Study 1	108	X	X			Concept Inventory, Survey
Study 2	76	X	X	X	X	Concept Inventory, Survey

Note: T1 and T2 took place in 2013; T3 and T4 took place in 2014.

T4), and (b) whether significant differences occurred between growth changes from T1-T2 and changes from T1-T4.

FINDINGS

Study 1

The 5-week computer science intervention had a significant positive effect on computer science knowledge (Mean diff= -7.39, t(102)= -19.6, p=.00) and positive attitudes towards computer science (Mean diff= -.38, t(107)= -4.24, p=.00) among high school girls of color. These data extend previous findings on the effect of culturally relevant and responsive computing interventions (Scott & White, 2013) and short-term computer science interventions (Martin & Scott, 2013), by demonstrating their effectiveness in impacting computing knowledge and attitudes for girls of color. There were small but non-significant changes in computer science college and career aspirations over the course of the intervention (Mean diff= -.09, t(107)= -1.07, p=.28; Table 2). The non-significant findings related to computer science aspirations suggest that additional intervention components or a more comprehensive intervention may be needed to transform computer science aspirations among girls of color.

Table 2. Paired-samples T-test results, by scale

Scale	Mean Diff (Pre-Post)	SD	*t*	Sig. (2-tailed)
Computer Science Knowledge	-7.39	3.82	-19.63	.000*
Computer Science Attitudes	-.38	.95	-4.24	.000*
Computer Science College and Career Aspirations	-.09	.87	-1.07	.287

*p<.10, **p<.05

Results indicate that the intervention had a significant positive effect on identification with computer science (M= -.28, t(102)= -3.37, p=.00) and after the computer science intervention, girls were more likely to see computer science as something that was relevant to their lives and their community. Girls' leadership skills (M= -.22, t(107)= -3.62, p=.00), access to diverse role models, and networks of peers in STEM also increased significantly from pre- to post-intervention (M= -.22, t(107)= -2.65, p=.00; M= -.40, t(107)= -5.14, p=.00). The endorsement of negative racial and gender stereotypes among girls of color decreased, although not significantly (M= -.06, t(107)= -.98, p=.33; M= -.03, t(107)= -.54, p=.59; Table 3). These findings indicate that a culturally relevant computer science intervention can impact the identification with computer science and the self-reported leadership skills of girls of color. Additionally, the access to diverse role models in STEM/CS and situating the intervention within a network of peers from diverse racial and gender backgrounds impacted perceptions of supportive role models and peer networks among high school girls of color. The non-significant effects of the intervention on the endorsement of racial and gender STEM stereotypes suggests that the deeply ingrained nature of stereotypes may require greater intervention to produce significant positive effects.

Study 2

To examine the extent to which the intervention effects persist after a year and determine whether the second year of exposure provides increases beyond the effects demonstrated in year one, data from 76 of the original 108 participants at T1 (2013 pre), T2 (2013 post), T3 (2014 pre) and T4 (2014 post) were collected and analyzed at the conclusion of the second year of the computer science intervention. At the conclusion of the first 5-week computer science intervention, significant gains were demonstrated among girls of color in computer science knowledge and attitudes,

Table 3. Paired-samples T-test results, by scale

Scale	Mean Diff (Pre-Post)	SD	*t*	Sig. (2-tailed)
Identification with Computer Science	-.282	.87	-3.37	.001**
Diverse Role Models in STEM/CS	-.226	.88	-2.66	.009**
Networks of Peers in STEM/CS	-.404	.82	-5.14	.000**
Leadership Skills	-.224	.64	-3.62	.000**
Endorsement of Racial Stereotypes (STEM)	.061	.06	.98	.327
Endorsement of Gender Stereotypes (STEM)	.027	.65	.54	.588

*p<.10, **p<.05

identification with computer science, leadership skills, and access to diverse role models and networks of peers in STEM and computer science. Non-significant effects were demonstrated in computer science aspirations and the endorsement of racial and gender STEM stereotypes. These variables were measured again after a full academic year to determine whether intervention effects persist in the absence of additional specific computer science interventions.

Self-reported computer science knowledge slightly decreased a year after the first intervention, and this decrease was statistically significant (M=3.04, SD=.86 to M=2.85, SD=1.0; t(70)=2.5, p=.01). Similarly, attitudes towards computer science also decreased significantly from post-program levels over the course of the academic year. These data suggest that interventions effects on computer science knowledge and attitudes are susceptible to slight regression in the absence of additional interventions. Interestingly, the extent to which students identified with computer science and aspired to pursue computer science in college and career not only held consistent, but increased significantly in the absence of additional interventions (M=2.8, SD=.95, M=3.15 SD=.96; t(68)=2.44, p=.01).

Significant increases in access to diverse role models, perceptions of supportive networks of STEM peers, and self-reported leadership skills demonstrated as a result of the intervention held steady a year after the intervention with no significant changes (Table 4). There were also no significant differences in the endorsement of

Table 4. Mean comparisons, by time interval and variable

Scale	2013 (Pre-Post Effect Sig.?)	2013 (Post-Mean)	2014 (Pre-Mean)	Mean Diff (Pre-Post)	2013 Post-2014 Pre (change sig?)
Computer Science Knowledge	Y	3.04	2.85	-0.19*	Y
Computer Science Aspirations	N	2.89	3.15	0.26*	Y
Attitudes towards Computers Science	Y	3.92	3.70	-0.20*	Y
Identification with Computer Science	Y	3.62	3.86	0.24*	Y
Diverse Role Models in STEM/CS	Y	3.55	3.59	0.04	N
Networks of Peers in STEM/CS	Y	4.38	4.27	-0.11	N
Leadership Skills	Y	3.80	3.72	-0.08	N
Endorsement of Racial Stereotypes (STEM)	N	1.44	1.38	-0.06	N
Endorsement of Gender Stereotypes (STEM)	N	1.18	1.30	0.12	N

*p<.10, **p<.05

racial or gender stereotypes a year after the intervention (these effects were initially non-significant). These findings provide promising data for understanding:

1. The lasting effect that a short-term intervention can have on the computer science aspirations, identification, and support networks among adolescent girls of color, and
2. Demonstrating that interventions to increase computer science knowledge may need repeated exposure in order to maintain significant growth in knowledge effects.

To determine the cumulative impact of a second summer of exposure to the computer science intervention and determine whether two summers of intervention produce greater outcomes, the mean growth of each variable from Summer 1 (T1-T2) was compared to the mean growth of each variable over two summers (Summer 1+2, T1-T4). Computer science knowledge and aspirations both demonstrated significantly higher growth over the course of two summers of intervention than just one summer, suggesting that repeated exposure to computer science courses and associated activities produces greater outcomes in content knowledge and aspirations. Students also demonstrated significantly greater growth in identification with computer science and leadership skills over two summers of intervention than a single exposure. Finally, two summers of exposure had significantly higher impact on reducing gender stereotypes among girls of color than just one summer (where the growth was non-significant; Table 5), which suggests that this repeated culturally relevant intervention can play a significant role in reducing gender stereotypes about STEM ability among girls of color. Interestingly, racial stereotypes appear more deep-rooted, and actually demonstrated larger growth and became more salient over two summers, rather than decreasing. There were no significant differences between 1 and 2 years of intervention exposure in access to diverse role models, having a network of peers in CS, and attitudes towards CS.

SOLUTIONS AND RECOMMENDATIONS

Results from this 2-part study examining the effectiveness of a culturally relevant computer science intervention to enhance computer science knowledge, attitudes, and aspirations among high school girls of color demonstrated several important findings in understanding ways to engage and enhance participation in computing among girls of color. Results from Study 1 demonstrate that a 5-week summer intervention (which included computer science curriculum, exposure to diverse role models and peers, and leadership development activities) produced significant

Table 5. Comparison of variable growth, by length of exposure to intervention

Scale	Summer 1		Summer 1+2		MEAN DIFF (Summer 1 Growth- Summer 1+2 Growth)
	(2013 Pre-Post Growth)	Sig. Growth (Y/N)	(2013 Pre-2014 Post Growth)	Sig. Growth (Y/N)	
Computer Science Knowledge	+1.24	.000** (Y)	+1.90	.000** (Y)	+.63**
Computer Science Aspirations	+.09	.411 (N)	+0.59	.000** (Y)	+.50**
Attitudes towards Computers Science	+0.44	.000** (Y)	+0.55	.000** (Y)	+.11
Identification with Computer Science	+0.26	.007**(Y)	+0.66	.000* (Y)	+40**
Diverse Role Models in STEM/CS	+0.16	.114 (N)	+0.02	.867 (N)	.14
Networks of Peers in STEM/CS	+0.42	.000** (Y)	+0.44	.000** (Y)	.01
Leadership Skills	+0.22	.001** (Y)	+0.47	.000** (N)	+.25**
Endorsement of Racial Stereotypes (STEM)	-0.07	.779 (N)	-0.27	.003** (Y)	-.19**
Endorsement of Gender Stereotypes (STEM)	-0.01	.252 (N)	+0.36	.000** (Y)	+.35**

Note: Pre-Post growth is reported in Mean differences; Mean values range from 1-5; *p<.10, **p<.05

increases in girls' knowledge of core computing concepts and their perceptions of computer science as an enjoyable and interesting subject. Further, the intervention increased girls' likelihood of perceiving computer science as relevant to their lives and their community and their self-reported leadership abilities. Finally, the intervention produced significant increases in their exposure to diverse role models and a supportive community of peers. These findings extend research on computing interventions by providing data indicating that this 5-week computing intervention implemented in an out-of-school setting with girls of color has a significant impact on computer science knowledge and attitudes. The small and non-significant changes in computer science college and career aspirations and the endorsement of racial and gender stereotypes about STEM ability suggest that a more intensive intervention (additional exposure/longer length of time) may be needed to transform positive attitudes and knowledge of computer science concepts into longer-term outcomes, including aspiring to pursue computer science as a career and reshaping perceptions about ability in STEM fields.

Building upon the results from Study 1, Study 2 demonstrated several important findings related to the endurance of intervention effects and the cumulative impact of multiple points of intervention. After a full academic year (9 months), there were no significant changes in access to diverse role models, peer networks, leadership skills, endorsement of stereotypes, and increases in computer science aspirations and identification with computer science. This suggests that these intervention effects endure in the absence of additional interventions and provide evidence for the lasting impact that a short-term intervention can have on the computer science outcomes among girls of color. The significant increases in computer science knowledge and attitudes demonstrated in Study 1, however, decreased significantly over the course of the academic year, suggesting that computer science knowledge and attitudes are susceptible to slight regression in the absence of additional interventions. These findings demonstrate that interventions to increase computer science knowledge may need repeated exposure in order to maintain significant growth in knowledge effects, which is critical information for the field as programs, curriculum, organizations, and initiatives to enhance diversity in computing continue to be developed and tested. Finally, confirming the hypothesis that 2 summers of intervention would produce greater gains among girls of color, Study 2 revealed that computer science knowledge and aspirations both demonstrated significantly higher growth over the course of two summers of intervention than just one summer. Similarly, students demonstrated significantly greater growth in identification with computer science, leadership skills, and reduction of endorsement of gender stereotypes over two summers of intervention, suggesting that repeated exposure produces greater outcomes among this population. Despite the significant impact on these variables, the endorsement of racial stereotypes was not impacted by repeated interventions, suggesting these stereotypes appear deep-rooted and salient and require additional intervention.

This research has numerous implications for practitioners in the design of interventions targeting girls of color and provides preliminary data for a model for effective programming for girls of color in computer science. This research indicates that:

1. Short-term interventions can be powerful and impactful,
2. More comprehensive interventions and longer-term interventions are needed to produce long-term effects on computer science knowledge, aspirations, and stereotypes.

These findings also provide data supporting a culturally relevant framework for computing interventions.

FUTURE RESEARCH DIRECTIONS

This research indicates that short-term computing interventions providing rigorous computer science curriculum within a culturally relevant out-of-school context can have a significant and lasting impact on computer science knowledge, attitudes, and aspirations among girls of color. Additionally, repeated exposure to this intervention resulted in greater growth in knowledge, aspirations, and aspirations than just one exposure, suggesting that interventions with multiple points of sequential exposure to computer science coursework will result in larger growth and more significant outcomes. Future research is needed to provide a comprehensive understanding of the impact of interventions on outcomes along the entire computer science pipeline, by examining:

1. Whether growth in knowledge and aspirations increases exponentially,
2. What is the optimal ratio of number of exposures to produce greatest returns in outcomes, and
3. How does an intervention at the high school level impact how many girls go on to take/pass Advance Placement Computer Science exams, declare computer science majors, and complete post-secondary degrees in computer science.

Additionally, qualitative data from student interviews and focus groups will be helpful to provide a more nuanced understanding of the most impactful and effective intervention components as well as which types of activities and curriculum content are most engaging, inspiring, and lead to greatest outcomes among girls of color. This future research will be critical to informing in- and out-of-school programming, curriculum development, and investments to broaden participation in computing.

CONCLUSION

Given the increased interest and imperative to address disparities in the computing pipeline affecting women and girls of color, this research provides insight into effective strategies and models to engage, inspire, and prepare underrepresented students to participate in computer science. Disparities in computing can be tied to both structural barriers to access and social/psychological barriers preventing underrepresented students from developing interest, identification, and confidence in pursuing computer science. As such, comprehensive interventions are needed to both provide access and dismantle social/psychological barriers while providing a culturally relevant context to build upon the strengths and interests of students. While this research provides findings on one specific intervention utilized within an out-of-school setting, it has implications for developing, implementing, and scaling computing interventions that will effectively impact preparation and participation in computer science among women and girls of color.

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KEY TERMS AND DEFINITIONS

Advanced Placement: College-level coursework undertaken in high school, culminating in an exam to determine university course credit; Advanced Placement courses are overseen by the College Board.

Computer Science (CS): The academic discipline of computer science. This term does not include the often conflated computer-based courses on information technology or computer literacy and usage.

Culturally Relevant Pedagogy: A framework for aligning pedagogy and curriculum with students' cultural background and building from strengths and interests in order to increase student engagement and academic outcomes.

Girls of Color: In this chapter, "girls of color" refers to young women from African-American/Black and Hispanic/Latino/a racial/ethnic backgrounds.

Intervention: A program, process, or behavior designed to intervene in order to change specific outcomes.

STEM: Abbreviation for the fields of Science, Technology, Engineering, Mathematics.

Underrepresented: A term used to describe the lack of representation within a specific population, context, or field; and within this chapter, "underrepresented students" is used to describe a demographic group of students who participate in computing at a lower proportion than their percentage in the overall population.