

eCSR: Creating Intensive Research Experiences that Cultivate Community for Undergraduate Women & Women of Color

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Abstract— The explore CS Research (eCSR) program is a university awards program created to support the design, development, and execution of research-focused workshops that provide opportunities for undergraduate women in Computer Science to learn more about research pathways and work on exploratory research problems. During the inaugural year of 2018-19, the program funded intensive research (IREs) workshops at fifteen universities across the nation, with 1,103 total student participants, 83% of whom were females, with a majority indicating Women of Color status. The intent of these workshops is to offer accessible research experiences to students who would not ordinarily participate in research, i.e. students from groups traditionally less exposed to computing (women, Women of Color, lower socio-economic status). The overall research questions guiding the study of the program are: does the program foster a sense of community, build skills, confidence and motivation among women to pursue computer science research; and, how do Women of Color experience this program? In this paper, we present findings from a mixed-methods study which demonstrate that IREs are effective at creating a positive research culture for undergraduate women. Factors that were found to be particularly salient for Women of Color are presented.

Keywords— Broadening Participation in Computing, Computer Science Education, Gender and Diversity, Undergraduate Research, Women of Color

I. INTRODUCTION

Women remain severely underrepresented in computer science degree attainment, despite a multitude of efforts across the country to attract and retain women in computer science (CS). Degree attainment in CS is 21% women for bachelor's degrees, 26% for master's degrees, and 19% for doctoral degrees [1]. Women of Color are severely underrepresented in CS, with 10% attaining bachelor's degrees [2]. Unless we change the current trajectory of women in CS pathways, it is predicted that faculty gender parity won't be attained until 2075 [3]. Gender parity in CS research is an essential goal because inclusive research teams increase innovation and creativity in the field [4], and democratize access to and application of computing [5]. Achieving parity among Women of Color in computing is especially important as it would greatly increase the economic

output in the tech sector, given the propensity for Women of Color to lead small businesses [2].

One approach to broadening participation of women in CS research is through undergraduate research programs (UREs). While UREs are generally effective recruiting and retention tools [6], mixed results have been shown regarding interest in pursuing graduate school [6][7]. Conditions that have been demonstrated beneficial to women in UREs include sense of belonging [8], mentoring [9], participation in technical conferences [10], and hands-on experiences [11][12]. Information about the graduate school admissions process, spotlighting gender topics, and applying research to social good, attracts women to research careers [12]. Creating a peer and faculty community that is warm and empathetic both within and outside the computing environment is essential [12][13][14].

Women of Color, i.e. Black and Latina women, face additional obstacles when pursuing CS, that pertain to intersectional identities and the 'double-bind' [15], yet most research treats women as a homogenous group, with Women of Color as 'invisible' [16]. Access to technology and anxiety are related to financial hurdles [17]. Psychosocial hurdles such as isolation and stereotype threat [18] contribute to conflicts with social identity and the lack of support from family and friends [16]. Particular to Women of Color, personable mentoring is critically important to bridge the social support divide [14].

II. PROGRAM RATIONALE AND DESIGN

This study seeks to investigate distinctions for women and Women of Color that motivate and support the pursuit of CS research, in order to shed light on practical features that support the inclusion of women from all ethnic backgrounds. The overall hypothesis guiding the investigation of the eCSR program is that Intensive Research Experiences (IREs) can be designed specifically for undergraduate women and scaled to create a supportive community of women to open pathways to CS research. Questions guiding this study include: does eCSR foster a sense of community, build skills, confidence and motivation among women to pursue CS research; how do Women of Color

experience eCSR; what encourages or hinders Women of Color in pursuit of CS research? Because women are not a homogenous group, this study explores salient factors for women across ethnic groups.

The distinguishing educational features of the eCSR program are the length of the experience, the engagement level, and the increased capacity for community. *The program innovation is in the scale and reach to the female undergraduate population.* While its design is based upon two exemplary IREs [19][20], eCSR has replicated these best practices at a national scale across a wide variety of institutional contexts, making this program unique in its reach to students of all backgrounds and exposure levels to CS.

Traditional undergraduate research programs offer 8 to 10 - week summer research experiences to small cohorts of approximately ten students from different colleges and universities, all of whom return to their respective institutions at the end of the program. The participation levels of women in these programs are marginal, hovering just below 30% among NSF funded programs [7]. Since CS degree enrollments across the country lack gender parity, research-based academic courses will not provide the critical mass of women to form community. The eCSR program provides IREs within a semester or academic year, and with large cohorts of students where women are in the majority, ranging from 40 to over 100 women at each program. Students are connected to peers and faculty while participating in hands-on research, to facilitate deep engagement in CS research.

Each of the 15 workshops was an intensive research experience (IRE), sharing common structural features to enable implementation fidelity across the program and addressing key factors known to support women and Women of Color (e.g. psychosocial support, graduate school seminars, socially relevant research projects). There were two structural options: a multi-day continuous workshop (n=10), or a sequential series of workshops throughout the academic year (n=5). Both workshop types were structured like a professional conference, with keynote speakers, panels, and breakout sessions. Breakout sessions focused on the research expertise from the institution and provided hands-on research activities for student teams. Collaborative team projects and mentoring occurred at all IREs, with many workshops culminating in project showcases. Research career planning topics were offered across all workshops, including graduate school financing, planning, and expectations. Workshops also included gender-focused topics such as work-life balance, stereotype threat, and imposter syndrome. A range of CS research areas was addressed, all framed within socially relevant applications. Structural decisions were made by the faculty leading the IREs at each institution and were based upon contextual factors pertinent to their respective student populations.

III. METHODOLOGY

A mixed-methods repeated measures study design was implemented using a pre/post survey of student participants, along with participant interviews. Surveys and interviews focused on these overarching indicators of program success for women in CS research: student perceptions of the research

experience (self-efficacy, attitudes towards computing, mentoring), skill development (research), and career identity (intent to pursue graduate school, scientific leadership and identity). The researchers met with the faculty workshop leaders prior to conducting the study to discuss implementation fidelity. Institutional Research Reviews were approved prior to the data collection at the primary researchers' respective institutions.

A. Survey Instrument

Surveys were administered via Qualtrics prior to the start of the workshop and repeated at the conclusion of the workshop. The instrument measured the following constructs: Self-Efficacy, Interest in Graduate School, Attitudes about Computer Science, Research Skills, Professional Identity. Additionally, there were two items designed to capture career and academic plans. Mentoring and Program Evaluation items were included at the post-survey, with the addition of open-ended items about likes and dislikes. All items were rated on a 5-point Likert type scale, with 5 being the most positive rating. Demographic items were included to capture gender, ethnicity, level in school, and socio-economic status (SES). Thirteen workshops elected to pilot a Sense of Belonging scale to measure connection to the CS research community. The survey instrument [21] is available upon request to the authors.

B. Interviews

Interviews were conducted at all workshops, using a semi-structured interview process that followed the six core constructs. Student interviews were conducted either during workshop events or shortly following the workshop events. Volunteer participants received a \$20 Amazon gift card. Interview protocols are available upon request to the authors

IV. PARTICIPANTS

A total of 525 students participated in the pre-survey (65% Women of Color, 21% low SES) and 365 participated in the post-survey (71% Women of Color, 19% low SES). Demographic information was closely matched for respondents at pre and post-survey. Response rates were 48% at pre-survey and 33% at post-survey. The SES item was collapsed into three categories of low, medium and high. Program evaluation items were collapsed into two thematic areas, connecting with others, and overall sentiments about the program. A total of 23 students were interviewed across the workshops. All participants were female; 77% identified as Women of Color and over half (55%) indicated they fell on the lower socio-economic scale.

V. ANALYSES

A t-test was performed to measure changes in the constructs between pre- and post-survey collection. Two multivariate analysis of variance (MANOVA) were conducted at pre and post-survey to examine differences in constructs by ethnicity; the ethnicity category was recoded into three types: White, Asian, and Women of Color. The Women of Color category contained students who selected African American, Hispanic/Latinx, Native Hawaiian/Pacific Islander, Native

American/American Indians, and Multi-ethnic. All analyses were performed in SPSS.

A semi-structured interview process was employed for workshop participants. Participants were recruited by announcements at the workshops and via a survey item. The phenomenological approach [22] was used to analyze data using Dedoose software to produce emergent thematic codes from all interviews.

VI. LIMITATIONS

As with all educational research, there are contextual confounds, e.g. prior research exposure, levels of participation, self-selection, and self-report bias. The assumption was that all participants engaged in the workshops as intended. Self-selection is mitigated by low construct scores at pre-assessment, an indication that the students were exploring their academic and career options and not firmly committed to CS research. A repeated measures design was selected to account for within subject populations, but matched pairs were not possible in all cases due to the voluntary participation in the survey. Combining ethnic groups obscures the particular cultural context of each identity, i.e. Hispanic/Latinx women undoubtedly have distinctive experiences from African American women. This choice was made in order to provide similar group sizes for statistical analysis. Self-report bias was addressed via qualitative investigation. It is beyond the scope of this study to examine any nuanced structural features that may relate to participant outcomes.

VII. RESULTS

Results from the survey indicate that all constructs increased at post-survey, with self-efficacy, graduate school interest, research skills and professional identity as a scientist increasing significantly (Table 1). Sense of Belonging was piloted at 13 of the workshops (and therefore omitted from the table), for which statistically significant positive gains were observed between pre- and post-survey. The mean score at pre-survey was 3.79 ($SD = .83$) and was 4.05 ($SD = .74$) at post-survey, $p = .001$. Mentoring and Program Satisfaction were offered at post-only, and were positive mean scores, 3.58 and 4.23 respectively.

The omnibus Wilks's lambda (Λ) was significant, $\Lambda = .883$, $F(12, 754) = 3.07$, $p < .001$, indicating the combined dependent variables differed, on average, between White, Asian, and Women of Color students at pre-survey. Follow-up univariate F statistics suggested significant differences as a function of ethnicity in graduate school interest, research skills and scientific identity. Specifically, Women of Color students had significantly higher levels of graduate school interest and scientific identity than White and Asian students, respectively. Women of Color students also had significantly higher levels of research skills than their White peers. At the post-survey, only graduate school interest showed a significant difference as a function of ethnicity, with Women of Color students having higher graduate school intention than White women.

Open-ended survey comments (Table 2) were examined resulting in four themes: Connecting with Others, Research Achievements, Learning, and Mentoring. Connecting with

others was conveyed by comments such as "collaborating with girls on the same boat as me;" and "becoming part of a new community." Research achievement was a distinguishable theme from Learning in that research achievements noted specific research tasks that were accomplished, e.g. "getting to know the research process," and "finishing the research project and seeing the results;" whereas Learning referred to generalized learning in CS and career options (e.g. "learning new programming languages," "learning how to fund masters").

TABLE I. SURVEY CONSTRUCT MEANS, STANDARD DEVIATIONS

Construct	Pre Mean/SD	Post Mean/SD
	(n=525)	(n=365)
Self-Efficacy	3.96 (0.82)	4.07* (0.72)
Graduate School Interest	3.64 (0.90)	3.80* (0.85)
CS Attitudes	4.46 (0.54)	4.48 (0.55)
Research Skills	3.05 (1.04)	3.84* (0.86)
Identity as Scientist	2.85 (0.97)	3.20* (1.03)
Mentoring	NA	3.58 (0.82)
Program: network	NA	4.34 (0.63)
Program: sentiment	NA	4.11 (0.77)
Response Rate	48%	33%

*indicates statistical significance at $p < .05$.

For the item about most rewarding experiences of the workshop, 55% of Women of Color indicated connecting with others, compared to 29% of white women and 48% of Asian women. White and Asian women reported research achievement as rewards, 20% and 12% respectively; Women of Color did not mention research achievements at all. When responding to the prompt for the least useful workshop components, half of the Women of Color indicated responses that the entire workshop was useful, with only 20% indicating specific components that were not useful. Comparatively, 38% of White and Asian women noted 'not applicable' responses, and 35% specified unhelpful components.

Interviews corroborated survey findings in that students increased their research skills, understanding of graduate school and how to apply, and developed a strong sense of community. The Women of Color indicated the benefits to be in becoming connected to a community of other Women of Color in CS. Many of the Women of Color discussed that they had *never had any mentors in the field of CS* prior to their attendance at these workshops and that the mentorship they received focused specifically on the challenges and biases that they face as Women of Color. *Mentoring by Women of Color* was crucial for developing a sense of belonging to the field. Feeling affirmed in the field *as Women of Color* was highly valued by the Women of Color, who attributed this affirmation to the relationships that they were able to develop with peers and faculty *who were also Women of Color*. A strong desire was voiced by most Women of Color interviewed to move the field forward, i.e.; not to move

themselves or their careers further, but to make computing (the field, the tools, the products) good for others.

TABLE II. SURVEY COMMENT THEMES BY ETHNIC GROUPS

Theme	Asian Women	White Women	Women of Color
Connections with Others	48%	29%	55%
Research Achievement	12%	20%	0
Learning	34%	27%	30%
Mentoring	4%	7%	7%

VIII. DISCUSSION AND CONCLUSION

This study contributes to the conversation about how women experience the CS research community and explores the nuances of women across ethnic groups. The eCSR program demonstrates that a positive research culture, so critical to women [11], was established at a large scale, replicated within various institutional settings, and provide a localized supportive community. Findings point to new implications for recruiting, community building, and mentoring Women of Color.

At pre-survey, Women of Color reported significantly higher interest in graduate school, research skills and scientific identity, a suggestion that recruiting Women of Color needs attention (e.g., recruiting for potential vs. confirmed interest). Personal relationships that extend beyond tactical advising are critically important, especially for Women of Color. Additionally, linking CS research to social good, advocacy and social welfare has been shown to be important for Women of Color [14]. The contribution of this work is in demonstrating that IREs are a unique and effective way of providing undergraduate women with peer engagement, so that they feel that they fit in CS research by engaging with others like themselves, which is particularly salient for Women of Color. These workshops are uniquely positioned to offer the critical mass of women needed for fostering sense of belonging [9].

Future investigation will consist of longitudinal participant follow up to measure degree and career attainment, and will include the examination of the influence of specific program features on outcomes, in an effort to better understand the conditions that work best for the myriad of intersectional identities of women.

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