CRA-W/CDC Alliance
Research Experiences for Undergraduates

Comparative Evaluation Report | 2011-2013

Prepared by
CRA's Center for Evaluating the Research Pipeline

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About CERP

The CRA Center for Evaluating the Research Pipeline (CERP) evaluates the effectiveness of intervention programs designed to increase retention of students from underrepresented groups in computing, namely women of all racial/ethnic backgrounds and men from underrepresented racial/ethnic groups. More generally, CERP strives to inform the computing community about patterns of entry, experience, progress, and success among individuals involved in academic programs and research careers related to computing.

CERP was created by the Committee on the Status of Women in Computing Research (CRA-W)/Coalition to Diversity Computing (CDC) Alliance and is funded by the National Science Foundation (NSF). Visit CERP online at http://cra.org/cerp/ or contact cerp@cra.org to learn more.

Executive Summary

The CRA-W and CDC are committed to increasing gender and racial diversity in computing fields. To that end, CRA-W and CDC formed an alliance to implement programs designed to improve the retention, experiences, and outcomes of underrepresented students in computing. In particular, CRA-W and CDC programs offer research experiences and mentorship to students with the ultimate goal of promoting a more diverse computing labor force. These programs specifically target women of any racial/ethnic background and men from underrepresented racial/ethnic groups. This report offers a summary of student outcomes in computing with a specific focus on how participants in CRA-W/CDC Research Experiences for Undergraduates (REUs; n = 154) compare to other computing students with and without research experience (i.e., non-participants; n = 3,228).

"My DREU and CREU experiences primarily contributed to me changing my mind about the highest degree I intended to pursue. I was planning on stopping with a bachelor's degree or, at most, going on to a master's as part of a future career, but my DREU and CREU research experiences helped me realize that I enjoy research and want to do that as my career (and a PhD is necessary for that)."

- CRA-W/CDC REU Participant

KEY FINDINGS

Compared to non-participants with and without research experience, CRA-W/CDC participants were significantly more likely to:

- Participate in professional networking opportunities
- Gain knowledge from their REU about the graduate admissions process
- Apply to graduate computing programs
- Enroll in PhD computing programs

Results suggest that it is important to continue offering formal research opportunities to computing students and to make these opportunities widely available to students of all backgrounds.

Introduction

"We cannot afford to leave behind those groups that have traditionally been underrepresented in computing . . . Without their participation, talents, and creativity, our Nation . . . cannot achieve . . . the innovations that will serve our highly diverse society." - *The National Science Foundation*

It is well established that computing fields lack demographic diversity. Although the number of women in science and engineering is growing, stark gender disparities persist in computing fields, with women earning only 18% of bachelor's degrees and 23% of graduate degrees in the computing sciences (NSF, 2012; see Figure 1). Notably, gender disparities in computing are consistent across all racial/ethnic groups in the United States (NSF, 2012). In addition, men from certain racial/ethnic groups, namely black, Latino, Native American, Alaska Native, and Native Pacific Islander men, are also underrepresented in computing fields, particularly at the graduate level (NSF, 2012; see Figure 1).

Why Diversity Matters

Dramatic gender and racial/ethnic disparities in the computing workforce may cause the field to miss out on the broad pool of talent necessary to address the computing needs of the 21st century. That is, when one demographic group dominates the field, computing lacks diverse perspectives and experiences that are critical to effective problem solving. In addition, when underrepresented groups are not involved in the creation of new technologies, their needs and desires as users may be overlooked. Attracting and retaining a diverse computing workforce is critical for maximizing innovation, creativity, and competitiveness in a global market.

Promoting a diverse computing workforce is also important for social and economic equity. When a culturally valued and high paying field like computing attracts and retains certain social groups more than others, underrepresented groups have relatively less opportunity for esteem and financial security. The persistence of this pattern of selective participation across groups may ultimately contribute to group-level disparities in economic power and status.

Importantly, the problems presented by low diversity in computing are recursive and self-perpetuating. When individuals lack peers and role models who are similar to them in terms of gender, race, and other important social identities, they begin to question whether they belong in the field. This sense of alienation and uncertainty can lead underrepresented individuals to avoid or drop out of computing, thus perpetuating a lack of diversity in the field (Dasgupta, 2011; Murphy, Steele & Gross, 2007; Walton & Cohen, 2007). All individuals, regardless

of gender, race, ethnicity, socioeconomic background, or disability status, should have the opportunity to pursue a career in computing and should feel welcomed and efficacious while doing so.

Initiatives to Broaden Participation

The CRA-W and CDC are working toward broadening participation in computing by providing mentorship, training, and professional networking programs for underrepresented individuals. This report focuses on two of CRA-W/CDC's programs for undergraduate students: Collaborative Research Experiences for Undergraduates (CREU) and Distributed Research Experiences for Undergraduates (DREU). CREU provides positive research experiences for teams of underrepresented undergraduates who work during the academic year and, in some cases, the following summer at their home institutions. DREU, by contrast, matches promising undergraduates from underrepresented groups with a faculty mentor for a summer research experience at the faculty member's home institution.

This Report

The Center for Evaluating the Research Pipeline (CERP) was created to evaluate the effectiveness of programs like those of the CRA-W and CDC. We administer surveys to computing students across the U.S. that allow us to compare the experiences and outcomes of students who participated to students who had not participated in CRA-W/CDC CREU and DREU programs. For the current report, we administered two types of surveys: one focusing on

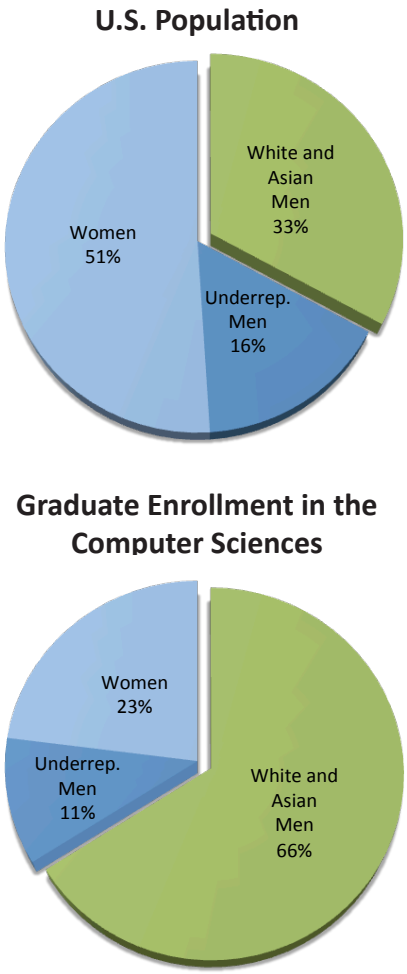

Figure 1. *Gender and racial/ethnic distribution of the U.S. Population (U.S. Census Bureau, 2010) and Graduate Enrollment in Computer Sciences (NSF, 2012).*

Note. Underrepresented men include men of Latino, Black, Native American, Alaska Native, and/or Native Pacific Islander background. Percentages based on U.S. citizens or permanent residents; excludes the racial category "other or unknown".

continuing students and factors relevant to *career preparation* and another focusing on **graduating students** and factors relevant to *career progression*. What follows is a report on the results of two years worth of aggregated data from the continuing student survey and three years worth of aggregated data from the graduating student survey.

Survey of Continuing Students

Methods

Procedure. During the fall of 2011 and 2012, 2465 undergraduate computing students from a broad range of computing departments at colleges and universities across the U.S. (N = 78 departments; see Table 1 for a list of participating universities) completed CERP's continuing student survey. The survey assesses students' past research and professional experiences, with a particular focus on factors relevant to career preparation, including knowledge, skills, and experience obtained through REUs. Survey items can be found in Appendix B.

Because the current report aims to assess the efficacy of the CRA-W/CDC's REU programs, we focus solely on students who either did or did not complete formal summer REUs at students' home institution, another institution or as part of an internship at a government or industry lab. We do not include less formal research experiences such as course-based research projects or independent study in our category of REUs, as these experiences are dissimilar in structure to CRA-W/CDC REU programs.

Survey Respondents. Survey respondents consisted of three groups: those who had participated in CRA-W/CDC REUs (n = 100), those who had participated in other REUs (n = 202), and those with no research experience (n = 2163). We further grouped respondents into underrepresented versus majority groups based on group representation in computing relative to the U.S. population (see Figure 1) . *Underrepresented students* consisted of women of all racial/ethnic backgrounds and men belonging to the following racial/ethnic groups: black, Latino, Native American, Alaskan Native, and Native Pacific Islander. *Majority students* consisted of white and Asian men. Whereas CRA-W/CDC REU participants consisted only of underrepresented students, respondents from the other two categories (other REU and no research experience) consisted of both underrepresented students (n = 867) and majority students (n = 1498). Figure 2 displays the gender and racial/ethnic background of the entire sample. Demographic information about each comparative group can be found in Appendix A, Figure 5.

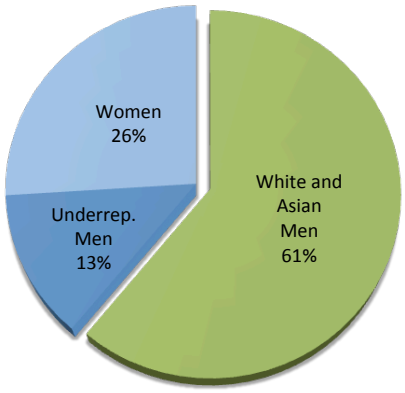

Figure 2. *Gender and racial/ethnic background of survey respondents.*

Table 1. *Participating universities.*

1. Albany State University
2. Allegheny College
3. Bryn Mawr College
4. California State University-Stanislaus
5. College of Saint Scholastica
6. Columbia University
7. CUNY Hunter College
8. CUNY Queens College
9. Dartmouth College
10. Eastern Washington University
11. Georgia Institute of Technology
12. Harvey Mudd College
13. Haverford College
14. Hendrix College
15. Indiana University
16. Jackson State University
17. Kean University
18. Miami University-Oxford
19. Millersville University of Pennsylvania
20. New Mexico State University Main Campus
21. Northwestern University
22. Oberlin College
23. Old Dominion University
24. Pennsylvania State University Main Campus
25. Purdue University
26. Radford University
27. Saint Joseph's University
28. Saint Mary's University of Minnesota
29. San Jose State University
30. Sonoma State University
31. Stanford University
32. SUNY College at Plattsburgh
33. SUNY Potsdam
34. Syracuse University
35. Texas A&M
36. Texas Southern University
37. Tougaloo College
38. Tufts University
39. University of Akron Main Campus
40. University of California Los Angeles
41. University of California San Diego
42. University of California Santa Barbara
43. University of Hartford
44. University of Hawaii at Hilo
45. University of Houston-Downtown
46. University of Illinois at Springfield
47. University of Illinois at Urbana Champaign
48. University of Illinois Chicago
49. University of Kansas
50. University of Maryland Baltimore County
51. University of Massachusetts Amherst
52. University of Michigan-Flint
53. University of Minnesota-Twin Cities
54. University of Minnesota-Morris
55. University of Missouri-Columbia
56. University of Nebraska at Kearney
57. University of Nevada-Reno
58. University of New Mexico-Main Campus
59. University of North Carolina at Chapel Hill
60. University of North Carolina at Charlotte
61. University of Pittsburgh
62. University of Puget Sound
63. University of South Florida-Main Campus
64. University of Texas at Dallas
65. University of Utah
66. University of West Florida
67. University of Michigan Ann Arbor
68. University of Pennsylvania
69. Utah State University
70. Virginia Tech
71. Washington University in St Louis
72. Wellesley College
73. Western Oregon University
74. Williams College
75. Winthrop University
76. Worcester Polytechnic Institute
77. Yale University

A Note About the Analyses

The analyses that follow exclude first year students because this group of students had not yet had the opportunity to participate in REUs. See Figure 4 in the Appendix for the distribution of students' class standing for each analytic group in the report.

Results

We assessed a variety of critical outcomes for comparative analysis of CRA-W/CDC participants versus non-participants. These outcomes included networking, mentoring received, career interest, graduate study intentions, as well as outcomes specific to those who had completed a summer research experience.

Professional Networking. As shown in Table 2, CRA-W/CDC participants experienced significantly more professional networking compared to non-participants. More specifically, compared to non-participants without research experience, CRA-W/CDC participants experienced significantly more professional networking through a broad array of opportunities, including REUs, conferences, workshops, work or internships, competitions, and lectures. By contrast, compared to non-participants with research experience, CRA-W/CDC participants experienced significantly more professional networking primarily through diversity conferences and REUs. In addition, compared to majority students with research experience, CRA-W/CDC participants experienced more networking through national computing conferences and mentoring workshops.

Table 2. *Professional Networking*

Contact with computing professionals or computing students/faculty outside of home institution at the following activities…	CRA-W/CDC REU	Other REU		No REU	
(1) None - (4) Quite a bit	Underrep	Underrep	Majority	Underrep	Majority
At a diversity conference	1.93	1.52*	1.10*	1.24*	1.06*
Through an REU	2.9	2.41*	2.13*	1.22*	1.17*
At a national computing conference	1.85	1.67	1.65*	1.53*	1.37*
At a networking or career mentoring workshop	1.85	1.67	1.55*	1.49*	1.36*
Through work or an internship	2.42	2.4	2.39	2.04*	2.13
At regional conferences or programing competitions	1.76	1.57	1.65	1.37*	1.36*
As speakers on campus or in the community	2.22	2.03	2.12	1.86*	1.76*
Mean Networking Experience	2.12	1.89*	1.77*	1.46*	1.42*

* $p < .05$; Comparison against CRA-W/CDC REU participants.
Note. Values indicate mean score across respondents.

Mentorship. Compared to non-participants without research experience, CRA-W/CDC participants were more likely to have a mentor, particularly from the academic community, including a research advisor, graduate student, academic advisor, former undergraduate instructor, other faculty member, or formal mentoring program (see Table 3). Compared to non-participants with research experience, however, CRA-W/CDC participants reported similar levels of mentoring with one exception: CRA-W/CDC participants were more likely to consider their research advisor as a mentor compared to majority non-participants. Overall, students with research experience (CRA-W/CDC or otherwise) were more likely to report having a mentor, and to report having a larger number of mentors, compared to students without research experience.

Table 3. *Mentorship*

Who do you consider to be mentor(s) to you as an undergraduate student?	CRA-W/CDC REU	Other REU		No REU	
	Underrep	Underrep	Majority	Underrep	Majority
Research advisor	68%	59%	53%*	6%*	7%*
Formal mentoring program	5%	1%	3%	2%*	1%*
Graduate student	26%	16%	23%	7%*	7%*
Academic advisor	71%	70%	61%	49%*	39%*
Former undergrad instructor	17%	19%	17%	9%*	9%*
Faculty member not officially assigned	44%	55%	47%	28%*	25%*
Undergraduate student	18%	29%	25%	20%	19%
Assigned member of advising office	12%	15%	16%	12%	11%
Nonacademic computing professional	10%	8%	13%	12%	11%
Adult family member	24%	30%	18%	24%	20%
Someone else	2%	3%	4%	6%	3%
No mentor	7%	9%	10%	27%*	35%*
Mean number of mentors reported	2.96	3.06	2.80	1.76*	1.53*

* $p < .05$; Comparison against CRA-W/CDC REU participants.
Note. Respondents could select more than one option. Values represent percentage within each group.

Research Career Interest. As indicated in Table 4, CRA-W/CDC participants expressed more interest in research careers compared to underrepresented students without research experience, but less interest compared to majority students with research experience. Interest in research careers did not differ among CRA-W/CDC participants and underrepresented non-participants with research experience. Together, these results indicate that research experience (whether through a CRA-W/CDC REU or other REU) is associated with greater research career interest among underrepresented students.

Graduate Study Intentions. Table 5 displays the extent to which students' summer experience (REU or otherwise) made it more or less likely that they would attend graduate school. Students who had participated in a CRA-W/CDC summer REU reported that the experience made it more likely that they would pursue a Master's degree in computing compared to students who had not participated in a summer REU. There were no differences between CRA-W/CDC participants and non-participants in other REUs.

Table 4. *Interest in a Research Career*

How interested would you be in having a computing job like the ones listed below?	CRA-W/ CDC REU	Other REU		No REU	
(1) Strongly disinterested - (4) Strongly interested	Underrep	Underrep	Majority	Underrep	Majority
University professor	2.60	2.49	2.99*	2.28*	2.50
Researcher in industry or government	3.17	3.13	3.45	2.90*	3.02

* p < .05; Comparison against CRA-W/CDC REU participants.
Note. Values indicate mean score across respondents.

Table 5. *Intent to pursue graduate study in computing.*

Did your summer experience make it more or less likely that you will do these things after graduation?	CRA-W/ CDC REU	Other REU		No REU	
(1) Much less likely - (5) Much more likely	Underrep	Underrep	Majority	Underrep	Majority
Study computing in graduate school	3.02	3.02	3.20	2.85	2.95
Attend graduate school immediately after undergrad	2.93	3.01	2.95	2.72	2.86
Earn a master's degree in computing	3.18	3.12	3.05	2.90*	2.94*
Earn a PhD in computing	2.95	2.81	2.93	2.70	2.80

* p < .05; Comparison against CRA-W/CDC REU participants.
Note. Values indicate mean score across respondents.

Summer Research Experiences. We also assessed outcomes specific to students' experiences in an REU program, including perceived gains in experience and knowledge as well as satisfaction with the experience. As such, analyses reported in this section pertain only to those who had completed an REU during the prior summer.

As shown in Table 6, CRA-W/CDC REU participants were equally satisfied with their REU experience compared to non-participants in other REUs. Furthermore, compared to non-participants in other REUs, participants in CRA-W/CDC REUs gained more experience with the publication process and gained more knowledge about how to get into graduate school. CRA-W/CDC participants also gained more knowledge about the value of computing and available career options compared to majority non-participants in other REUs.

Table 6. *REU Experiences.*

	CRA-W/ CDC REU	Other REU	
	Underrep	Underrep	Majority
	n = 59	n =85	n = 112
Satisfaction with…			
(1) Very dissatisfied - (4) Very satisfied			
Supervisor's style	3.33	3.43	3.39
Team dynamics	3.32	3.47	3.32
The research experience	3.20	3.37	3.27
Experience gained through your REU…			
(1) No more than I had - (4) Quite a bit more			
Publication process	2.76	2.29*	2.14*
Research methodology	2.70	2.59	2.63
Collaboration	3.07	3.20	3.00
Knowledge gained through your REU…			
(1) No more than I had - (4) Quite a bit more			
How to get into graduate school	2.60	2.01*	1.79*
How computing can make a positive contribution to society	2.97	2.71	2.48*
What career options are available within computing	2.80	2.53	2.26*

* $p < .05$; Comparison against CRA-W/CDC REU participants.
Note. Values indicate mean score across respondents.

Survey of Graduating Students

Methods

Procedure. During the spring of 2011, 2012, and 2013, 917 undergraduate computing students who were on track to graduate completed CERP's graduating student survey. The graduating student survey assesses students' past research and professional experiences, as well as students' actual progression toward a research career in computing. Survey items can be found in Appendix B.

Survey Respondents. Respondents were categorized into three groups: those who had participated in CRA-W/CDC REUs (n = 54), those who had participated in other REUs (n = 267), and those with no research experience (n = 596). We defined REUs in the same way as we did for the continuing student survey.

We further grouped respondents into underrepresented versus majority groups; these categories were comprised of the same gender and racial/ethnic groups detailed in the continuing student survey analysis. Whereas CRA-W/CDC REU participants consisted only of underrepresented students, respondents from the other two categories (other REU and no research experience) consisted of both underrepresented students (n = 295) and majority students (n = 568). Figure 3 displays the gender and racial/ethnic background of the entire sample. Demographic information about each comparative group can be found in Appendix A, Figure 6.

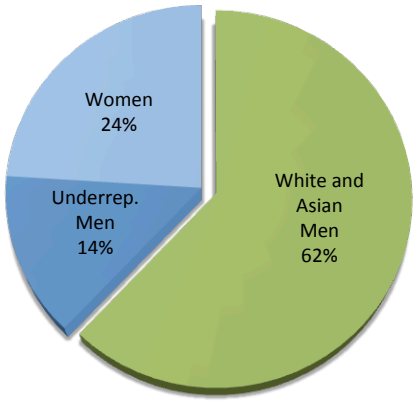

Figure 3. *Gender and racial/ethnic background of survey respondents.*

Results

We assessed a variety of critical outcomes for comparative analysis of CRA-W/CDC participants versus non-participants. These outcomes included professional networking experiences, received mentorship, confidence and knowledge about computing careers, and applying to and enrolling in graduate computing programs.

Professional Networking. As shown in Table 7, CRA-W/CDC participants reported significantly more participation in professional conferences and society

memberships compared to non-participants without research experience. Compared to non-participants with research experience, however, CRA-W/CDC participants reported similar levels of participation in professional conferences and society membership. In addition, students in all comparison groups reported similar levels of participation in social networking.

Confidence and Knowledge. We assessed confidence and knowledge about computing using multi-item constructs; individual items can be found in Appendix B. As indicated in Table 8, CRA-W/CDC participants reported significantly more confidence about their future success in computing relative to underrepresented non-participants without research experience. CRA-W/CDC participants also reported being more knowledgeable about the graduate school admission process compared to non-participants without research experience and compared to majority non-participants with research experience. Together, these results suggest that research experience (whether through a CRA-W/CDC REU or otherwise) may be important for contributing to the confidence and knowledge of students who belong to underrepresented groups.

Table 7. *Professional Networking*

Have you participated in any of the following computing-related activities outside your university?	CRA-W/ CDC REU	Other REU		No REU	
(1) None - (4) Quite a bit	Underrep	Underrep	Majority	Underrep	Majority
Professional conference	69%	59%	34%	24%*	16%*
Society memberships	37%	31%	24%	17%*	15%*
Computing-related social networking (e.g., blogs, listervs, Facebook groups)	44%	52%	53%	34%	38%

* p < .05; Comparison against CRA-W/CDC REU participants.
Note. Respondents could select more than one option. Values represent percentage within each group.

Table 8. *Confidence and knowledge*

	CRA-W/ CDC REU	Other REU		No REU	
(1) Not at all - (4) Very	Underrep	Underrep	Majority	Underrep	Majority
Confidence about future computing success	3.47	3.44	3.63	3.05*	3.29
Knowledge of graduate admissions process	2.96	2.81	2.56*	2.36*	2.29*

* p < .05; Comparison against CRA-W/CDC REU participants.
Note. Values indicate mean score across respondents.

Mentorship. Overall, students with research experience (CRA-W/CDC or otherwise) were more likely to report having a mentor, and to report having a larger number of mentors, compared to students without research experience (see Table 9). Additionally, CRA-W/CDC participants in particular were more likely to have a mentor from a formal mentoring program compared to all non-participants. CRA-W/CDC participants were also more likely to have mentors from various sources compared to non-participants without research experience, particularly majority non-participants without research experience.

Table 9. *Mentorship*

Who do you consider to be mentor(s) to you as an undergraduate student?	CRA-W/ CDC REU	Other REU		No REU	
	Underrep	Underrep	Majority	Underrep	Majority
Research advisor	54%	46%	49%	7%*	9%*
Formal mentoring program	9%	2%*	2%*	2%*	0%*
Graduate student	28%	24%	17%	10%*	10%*
Academic advisor	59%	58%	52%	50%	44%*
Former undergrad instructor	15%	21%	23%	17%	14%
Faculty member not officially assigned	56%	59%	46%	42%	38%*
Undergraduate student	22%	26%	32%	19%	24%
Assigned member of advising office	15%	15%	13%	14%	11%
Nonacademic computing professional	13%	16%	10%	11%	17%
Adult family member	9%	2%*	2%*	2%*	0%*
Someone else	59%	58%	52%	50%	44%*
No mentor	0%	12%	7%	18%	24%*
Mean number of mentors reported	3.02	3.06	2.68	2.01*	1.95*

* $p < .05$; Comparison against CRA-W/CDC REU participants.
Note. Respondents could select more than one option. Values represent percentage within each group.

Applying to and Enrolling in Graduate School. As shown in Table 10, CRA-W/CDC REU participants were significantly more likely to have applied to a graduate computing program compared to all non-participants. Most students who applied to a graduate computing program received letters of recommendation from a computing professor, although this was more likely among CRA-W/CDC REU participants compared to majority non-participants without research experience. In addition, CRA-W/CDC REU participants were more likely than all non-participants to receive letters of recommendation from mentors outside their home institution. Not only were CRA-W/CDC REU participants more likely to apply to a graduate computing program, they were also more likely to enroll in a PhD computing program in the ensuing fall semester compared to all non-participants.

Table 10. *Application and enrollment in graduate school*

	CRA-W/ CDC REU	Other REU		No REU	
	Underrep	Underrep	Majority	Underrep	Majority
Applied to graduate computing program	46%	29%*	30%*	26%*	16%*
Enrolled in PhD computing program	30%	11%*	9%*	1%*	1%*
Of those who applied, received recommendation letter from:					
Mentor outside of home institution	48%	16%*	20%*	0%*	14%*
Professional contact	4%	23%	31%*	23%	25%
Professor in computing area	88%	97%	96%	83%	66%*
Professor in non-computing area	4%	16%	20%	20%	11%

* $p < .05$; Comparison against CRA-W/CDC REU participants.

Note. Values represent percentage within each group. Respondents could select more than one option to indicate who wrote their recommendation letters.

Summary and Conclusion

Our results indicate that participation in a summer REU is associated with factors relevant to career preparation and progression. Students who had participated in an REU (CRA-W/CDC or other) during the prior summer reported more professional networking experiences, more mentors, more interest in a research career, and were more likely to pursue a graduate degree in computing, compared to students who had not participated in a summer REU. These results suggest that providing REU opportunities to a diverse array of computing students may help increase diversity in the computing research career pipeline[1].

> ***"It was a slow process to change my mind [to pursue a PhD in computing]...the most important factor was the DREU experience between my senior and 5th year senior years."***
>
> - CRA-W/CDC REU Participant

Notably, CRA-W/CDC REU participants showed additional benefits compared to students in other REUs. CRA-W/CDC participants reported more professional networking experiences, more experience with the publication process, greater gains in knowledge about graduate school, and were more likely to apply to and enroll in a PhD computing program compared to students in other REUs. Impressively, 30% of CRA-W/CDC REU participants reported enrolling in a PhD computing program in the upcoming fall. CRA-W/CDC REUs thus seem to be particularly effective in preparing underrepresented students to apply for and enroll in research-focused graduate programs in computing, which is one of the primary goals of the CRA-W/CDC Alliance.

"I really enjoyed all the interaction with my primary mentor (faculty) and my secondary mentor (a postdoctoral researcher) [during my REU]. Both really urged me to go to graduate school and their stories of how they ended up where they are was inspiring."

- CRA-W/CDC REU Participant

[1] As with any correlational data, results reported here should be interpreted with caution, as causality is unclear. Students self-select to participate in REUs, so any differences found between students with versus without research experience may be due to self-selection biases rather than research experience per se.

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Appendix A: Sample Characteristics

Continuing Student Survey Sample

Academic Background. Figure 4 displays the academic characteristics of each comparative group, namely class standing and highest level of mother and/or father education. As shown in the left panel of Figure 4, respondents were primarily third- and fourth-year students. In addition, as shown in the right panel of Figure 4, a large proportion of respondents reported having at least one parent with a Master's degree or higher (38%). However, a considerable proportion of respondents had parents with only a high school education or less (12%).

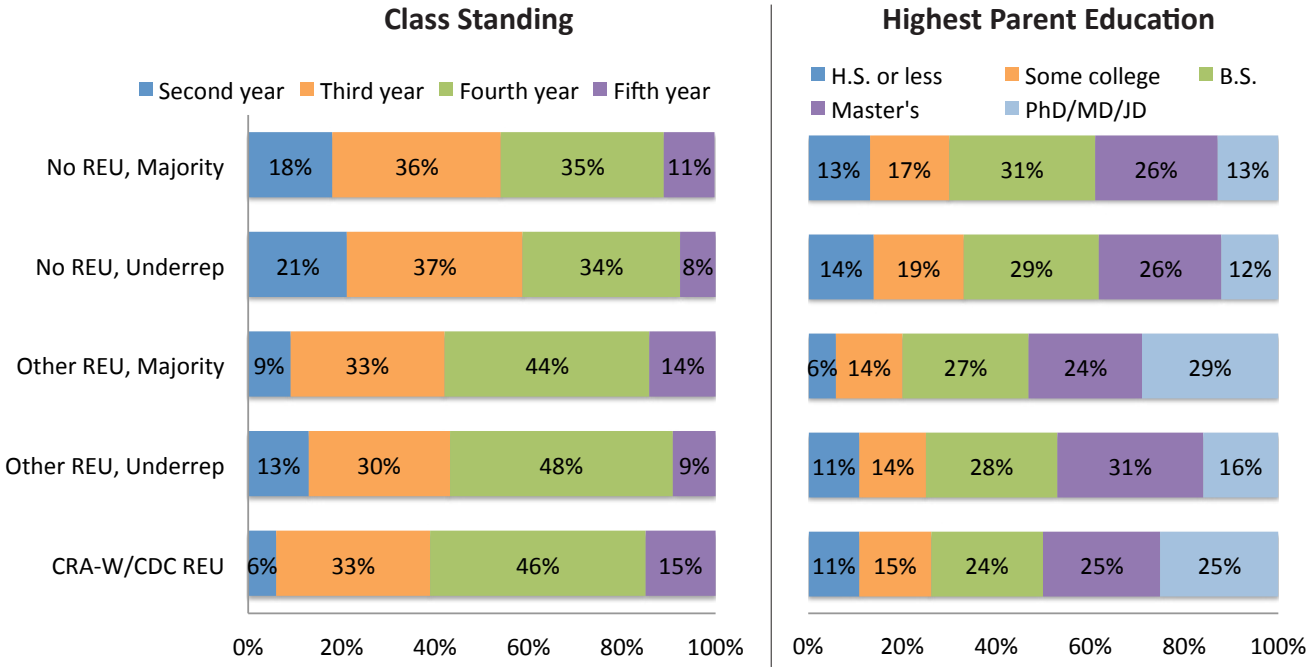

Figure 4. *Academic background of respondents to the continuing student survey within each comparison group.*

Gender, Age, and Racial/Ethnic Profile. Figure 5 provides the gender and racial/ethnic profile of each comparative group. Overall, most respondents identified as white (65%), followed by Asian (16%), black (9%), and Latina/o (7%). Respondents were primarily male (77%) and ranged in age from 18 to 60 (M = 24.24, SD = 6.43). The vast majority of the sample held U.S. citizenship or permanent residency (95%).

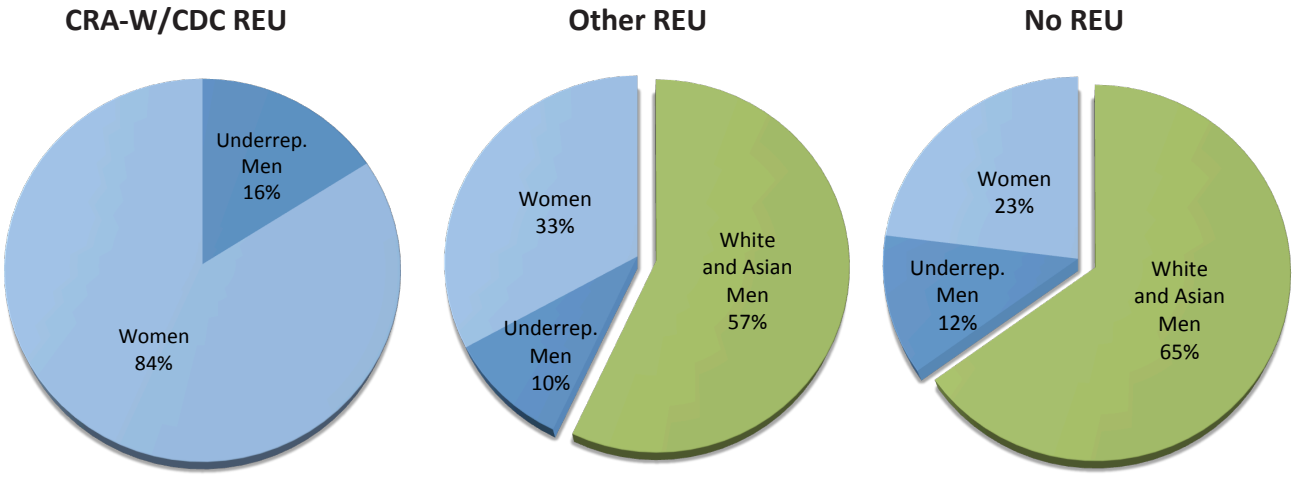

Figure 5. *Gender and racial/ethnic distribution of respondents to the continuing student survey within each comparison group.*

Graduating Student Survey Sample

Gender, Age, and Racial/Ethnic Profile. Figure 6 provides the gender and racial/ethnic profile of each comparative group. Overall, most respondents identified as white (65%), followed by Asian (15%), black (9%), and Latina/o (8%). Respondents were primarily male (77%) and ranged in age from 18 to 57 (M = 24.91, SD = 5.52). The vast majority of the sample held U.S. citizenship or permanent residency (94%).

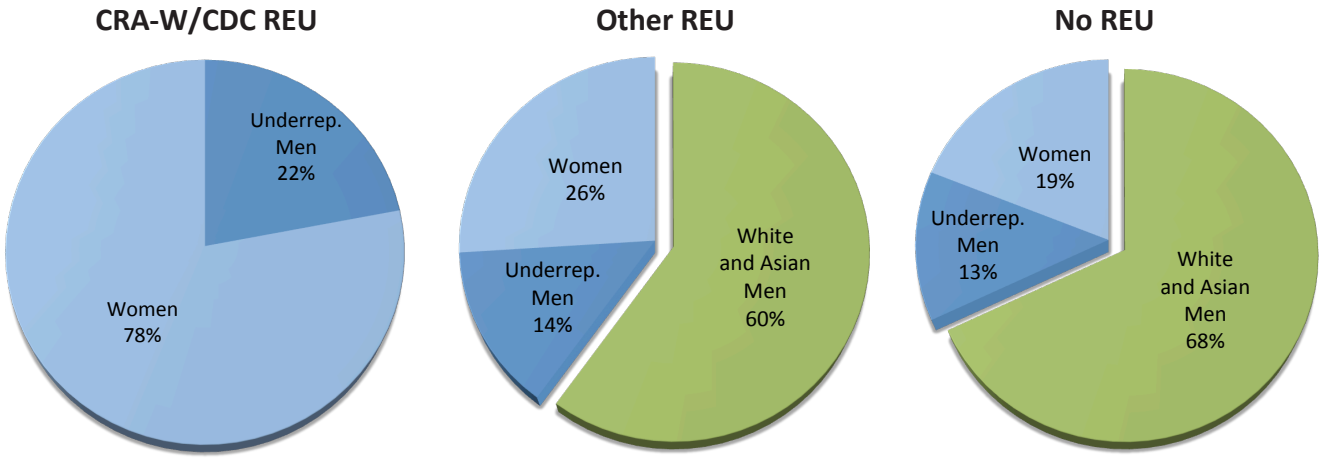

Figure 6. *Gender and racial/ethnic distribution of respondents to the continuing student survey within each comparison group.*

Appendix B: Survey Items

We determined reliability for multi-item constructs using Cronbach's alpha (α). Alpha levels ≥ .70 are considered acceptable.

Professional Networking

Continuing Student Survey. How much contact, if any, have you had with computing professionals or computing students/ faculty from outside your institution through the following activities?

(1) None (2) Almost none (3) Some (4) Quite a bit

- At a diversity conference such as Grace Hopper or Tapia
- Through a Research Experience for Undergraduates (REU)
- At a national computing conference
- At a networking or career mentoring workshop
- At regional conferences or programming competitions
- As speakers on campus or in the community

Graduating Student Survey. To what extent have you participated in the following computing-related activities outside your university?

(1) None (2) Almost none (3) Some (4) Quite a bit

- Professional conference
- Society memberships
- Computing-related social networking (e.g., blogs, listservs, Facebook groups)

Mentorship

A mentor is someone with whom you have an ongoing relationship, who provides you advice and assistance in advancing in your career. Who, if any, of the following do you consider to be mentor(s) to you as an undergraduate student? (Check all that apply).

- My research advisor.
- A mentor I met through a formal mentoring program sponsored by an outside organization.
- A graduate student or postdoc.
- My academic advisor who is a faculty member.
- A former undergraduate instructor
- A faculty member who is not officially assigned to mentor me.
- A fellow undergraduate student.
- My assigned member of the advising staff.
- A non-academic computing professional.
- An adult family member or family friend.
- Someone else
- I do not have a mentor

Research Career Interest

How interested would you be in having a computing job like the ones below after you finish your highest degree? Assume that you would be able to find a job in this area if you wanted to.

(1) Strongly disinterested *(2) Somewhat disinterested*
(3) Somewhat interested *(4) Strongly Interested*

- College/University professor
- Researcher in industry or government lab investigating new principles about computer hardware and software

Graduate Study Intentions

Did your summer experience make it more or less likely that you will do these things after graduation?

(1) Much less likely *(2) Somewhat less likely* *(3) Unchanged*
(4) Somewhat more likely *(5) Much more likely*

- Study computing in graduate school
- Attend graduate school immediately after undergrad
- Earn a master's degree in computing
- Earn a PhD in computing

Satisfaction with Summer REU

We assessed students' satisfaction with their summer REUs across three constructs: supervisor's style (5 items, α = .89), team dynamics of the research group (three items, α = .77), and the research experience (9 items, α = .92). Items for each construct were averaged together to form composite scores. Individual items are listed below.

How satisfied or dissatisfied were you with the following aspects of your summer research experience?

(1) Very dissatisfied (2) Somewhat dissatisfied (3) Somewhat satisfied (4) Very satisfied

Supervisor's style (α = .89)

- Your relationship with your research supervisor
- How often you met with your research supervisor
- The research guidance your supervisor provided
- The career advice your supervisor provided
- Fairness (absence of discrimination) within your research team

Team dynamics of the research group (α = .77)

- Your relationship with other undergraduates participating in the same project or lab
- Your relationship with graduate students or postdocs participating in the same project or lab
- Being part of a research community

The research experience (α = .92)

- Your research topic
- Your experience conducting research
- The type of work expected of you
- How well your skills matched the project
- How well your interests matched the project
- Your increasing independence over the course of the summer
- How well your skills matched the project
- Your ability to complete your research within the summer, or continue it
- How much input you had on what your work should be

Experiences Gained Through Summer REU

We assessed the amount of experience students gained through their summer REUs across three constructs: publication process (3 items, α = .83), research methodology (five items, α = .86), and collaboration (2 items, α = .72). Items for each construct were averaged together to form composite scores. Individual items are listed below.

How much experience, if any, did you gain through your summer research experience in these activities?

(1) No more than I had (2) Almost no more (3) Some more (4) Quite a bit more

Publication process (α = .83)

- Writing or co-authoring a research paper or report
- Publishing a research paper or report
- Summarizing published research results

Research methodology (α = .86)

- Using scientific methods to test a hypothesis
- Generating hypotheses
- Collecting data or conducting experiments
- Analyzing data with statistics or other tools
- Explaining results

Collaboration (α = .72)

- Collaborating with colleagues
- Feeling like a member of a research community

Knowledge Gained Through Summer REU

We assessed the amount of knowledge students gained through their summer REUs across three constructs: how to get into graduate school (3 items, $\alpha = .92$), value of computing (single item), and available career options (single item). Items assessing knowledge about how to get into graduate school were averaged together to form a composite score. Individual items are listed below.

How much knowledge about these topics, if any, did you gain from your summer experience?

(1) No more than I had (2) Almost no more (3) Some more (4) Quite a bit more

How to get into graduate school ($\alpha = .92$)
- Criteria for admission to graduate programs
- How to get financial support for graduate school
- How to select the right graduate program for you

Value of computing
- How computing can make a positive contribution to society

Available career options
- What career options are available within computing

Confidence About Future Computing Success

We assessed students' confidence about future computing success with five items. We averaged across items to form a composite score ($\alpha = .87$). Individual items are listed below.

How confident are you that, if you choose, you can successfully...

(1) Not at all confident (2) Only slightly confident (3) Moderately confident (4) Very confident

- Contribute to a research project in computing
- Get admitted to graduate school in computing
- Complete a graduate degree in computing
- Become a capable researcher in computing
- Have a successful career in computing

Knowledge About Graduate Admissions Process

We assessed the extent to which students felt knowledgeable about the graduate admissions process with three items. We averaged across items to form a composite score (α = .88). Individual items are listed below.

How knowledgeable do you feel about...

(1) Not at all knowledgeable *(2) Slightly knowledgeable*
(3) Moderately knowledgeable *(4) Very knowledgeable*

- What the criteria are for admission to graduate programs
- How to get financial support for graduate school
- How to choose the right graduate school for you

Applying to Graduate School

During the current school year, did you apply to graduate school in computing? (Include applications in progress but not yet complete).

- Yes
- Not yet, but plan to apply
- No, because was already admitted to a joint bachelors/masters program in computing
- No

Note. Table 10 indexes whether or not students selected "Yes".

Recommendation Letters

Who wrote your recommendations for your graduate school/ professional school applications? (Check all that apply).

- Mentor outside your institution
- Professor in computing area
- Professor in non-computing area
- Professional contact
- Other
- I did not need recommendations

Enrollment in a PhD Computing Program

A. What do you expect to be doing in the upcoming fall? (Check all that apply).

- Attending graduate school in a computing field
- Attending graduate or professional school in a non-computing field
- I am waiting to hear about graduate school applications in computing
- I am waiting to hear about graduate or professional school applications in a non-computing field
- Working in a computing-related job
- Working in other than a computing job
- I am waiting to hear about job applications
- Don't know
- Other

B. Please tell us about the computing graduate program you will be attending this fall.

- Master's, continuation of a joint BS/MS program
- Master's
- Master's (intend a PhD, but my department requires that I enroll in a master's program to start)
- PhD
- Other

Note. Table 10 indexes whether or not students selected both "Attending graduate school in a computing field" in section A and "PhD" in section B.