Improving Diversity in Computing Research: An Overview of CRA-W Activities

Lori A. Clarke
University of Massachusetts Amherst
clarke@cs.umass.edu

Lori Pollock
University of Delaware
pollock@udel.edu

Jane G. Stout
Computing Research Association
jane@cra.org

Carla Ellis
Duke University
carla@cs.duke.edu

Tracy Camp
Colorado School of Mines
tcamp@mines.edu

Betsy Bizot
Computing Research Association
bizot@cra.org

Kathryn S. McKinley
Google
ksmckinley@google.com

ABSTRACT

The Committee on the Status of Women in Computing is an action-oriented committee of the Computing Research Association with the goal of taking positive action to increase the number and success of women in the Computer Science and Engineering research pipeline. This paper describes CRA-Ws major programs and highlights some of their impacts as demonstrated through evaluation.

KEYWORDS

CS Ph.D. research pipeline, CRA-W programs.

1 INTRODUCTION

Computing is a major driving force of innovation. To increase participation in computing, we need to increase participation from all groups in society. The business case for the value of a diverse workforce is compelling. A 2007 NCWIT study shows that IT patents issued to mixed gender teams are cited 26 to 42% more than similar IT patents by all men or all women teams [1]. Herring [2] found that companies with reported highest levels of racial diversity had 15 times more sales revenues than those with lower diversity. In addition, companies with higher levels of gender diversity had more customers than those with lower levels. In the mid-1990s, IBM expanded their minority markets by promoting diversity in its own workforce [3]. Another study [4] found that having multi-cultural experience enhances creativity. There is considerable evidence showing that having a diverse group of contributors leads to better outcomes.

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The lack of diversity is particularly alarming in research careers requiring graduate degrees. Women and minorities continue to be a small fraction of computing Ph.D. recipients in the US, as shown in Figure 1. Although the percentages differ by countries, the overall trends tend to be similar; showing that women receive far fewer Ph.D.'s than men, although this is not the case for many other disciplines.

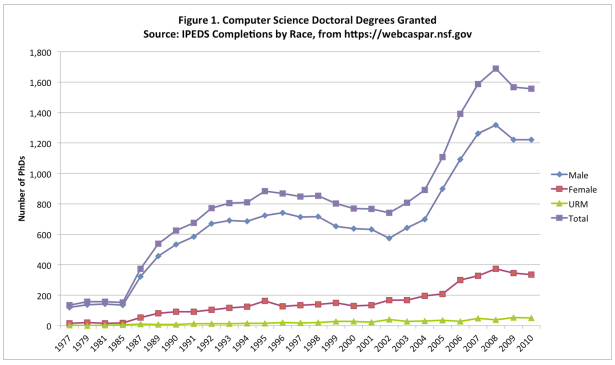

Figure 1: US Computer Science Doctoral Degrees Awarded.

The Computing Research Association (CRA) represents just about all Computer Science and Engineering (CS&E) Ph.D. granting institutions in the US and Canada, and most of the major CS-oriented industrial research laboratories. It monitors and advocates for policies that promote and foster computing research and computing researchers. The CRA Committee on the Status of Women in Computing (CRA-W) was established in 1991 with the goal of taking positive action to increase the number and success of women in the CS&E research pipeline. CRA-W is an action-based committee comprised of prominent, dedicated, senior women. CRA-W members are volunteers who give of their time and energy to design and implement projects and to secure funding needed to sustain those projects. Since its inception in 1991, CRA-W programs have had a direct impact on almost 25,000 women, underrepresented minorities, and persons with disabilities, and indirectly influenced thousands of others.

CRA-W has developed and implemented programs for all stages of the research pipeline from undergraduates through industry and faculty researchers with the goals to increase and sustain participation in computer science research by encouraging members of women and other underrepresented groups to earn advanced degrees in CS&E and to pursue research careers in academia or industry. This paper highlights the main programs offered to provide support throughout this pipeline with evaluation results indicating some of the impacts of the interventions. Some of these programs were carried out with cooperation from other organizations concerned with improving diversity in CS&E, most notably the Coalition to Diversify Computing (CDC).

2 CRA-W PROGRAMS

2.1 Undergraduates

Distributed Research Experiences for Undergraduates. Since 1994, the DREU program (formerly DMP, Distributed Mentoring Project) has matched outstanding women undergraduates with women faculty mentors for a summer of research at the mentor's institution. Starting in 2007, the CRA joined forces with the CDC to broaden the outreach of DREU to include underrepresented minorities (URMs), including men and women. In the two years prior to formation of the Alliance (2005-2006), just 12% of participants were URMs. Since the formation of the Alliance (in 2007-2008), underrepresented minorities grew to 34%.

DREU students participate in a 10-week research project, observe graduate student life, and benefit from a close mentoring relationship with their DREU advisors at the host research university. The learning experience begins during the application process that is modeled upon the graduate school application, requiring letters and a research statement. Over the summer, the students gain research experience and build confidence. They engage in key aspects of the research process such as contributing to the writing of research papers for submission and presenting results in poster sessions at conferences. Their research experiences make them more competitive when applying for graduate admissions and fellowships. DREU students receive support for transportation to the mentor's institution, a weekly stipend, and funding to attend a research conference with their mentor to present the results of their work. The DREU program defines milestones and expectations, including a web page and reports from the mentor and mentee. These activities unify aspects of the experience for all participants, in spite of differing research projects and locations. Since 1994, almost 1000 students have participated in this one-on-one mentoring program.

Collaborative Research Experiences for Undergraduates. Started by CRA-W in 1998, the primary goal of CREU has been to provide undergraduates with research experiences at their home institutions that will increase their likelihood of continuing on to graduate school. The students work at their home institution during the academic year on research projects, most often, in teams of two or three students under the guidance of a faculty member. There is an optional extension of an academic-year project into the summer. Students are selected on a competitive basis from mini-grant-like proposals written jointly with their mentor. Students gain insights into the research process, learn teamwork skills, develop confidence in tackling open-ended problems, and form a close working relationship with a faculty mentor. Research experience makes them more competitive in applying for graduate school and fellowships.

2.2 Graduate Students

Graduate Cohort. Since 2004, the CRA-W Grad Cohort Project has been building a community of women researchers in their early years in graduate school, with the goal of improving their graduate school experience and increasing retention. For the first Grad Cohort Workshop, 100 graduate students applied and participated. This year, 2018, we received over 1500 applications and expect to have funding to support about a third of the applicants, thanks to generous support from Industry, ACM, CRA, National Science Foundation, Department Of Energy, IEEE-CS, and several ACM-SIGs (including SIGSOFT). In addition, many CS&E departments provide funds so that more of their women students can participate. This year, fifty-four departments provided such funding. We believe that this level of participation by industry, professional societies, and academic departments shows tremendous support and appreciation from the computing community.

The workshop is structured into sessions with topics that relate to the first three years in graduate school. Topics include "Networking," "Presentation and Verbal Communication Skills," "Finding a Research Topic," as well as others. We invite women leaders in CS&E from academia, industry, and government labs to lead the sessions. Speakers serve as role models, give practical advice and information on navigating grad school, and provide personal insights on the challenges and rewards of their own careers. The workshop provides individual resume/cv reviews and individual career advising sessions, as well as networking opportunities and peer support among students at similar stages of their early graduate careers.

We make every attempt to select students so that all institutions with eligible applications are represented. We then encourage students when they return home to serve as ambassadors at their home institutions by sharing what they learned. See http://cra.org/cra-w/gradcohortworkshop/ for more information about Grad Cohort and to see the slides of the presenters and agendas for past years.

Discipline-specific Workshops. A DSW provides mentoring support and builds communities of women and other underrepresented researchers within the context of specific sub-disciplines of computing. While most CRA-W efforts are aimed at participants in all computing disciplines, field-focused efforts aim to build specific sub-discipline research knowledge, perspective, and community. Topics that differ by discipline are, for example, discussions about the most desirable and appropriate conferences and journals, where to apply for funding, and emerging hot topics. DSWs offer in-depth technical discussions that give participants

detailed information and skills to increase their ability and confidence to succeed and thrive.

A major focus of DSW is community building. The goal is for underrepresented groups to network and build a community within their subfield. The peers and senior researchers they meet at a DSW will be people they continue to see regularly at their field's topical research conferences. Having an established community of researchers can lessen the isolation felt when attending the large conferences. DSWs also offer an excellent opportunity to expand the CRA-W volunteer base since these events are often proposed and led by people who have not yet actively participated in other CRA-W activities.

While the original format was that of a two to three-day summer school for graduate students, variations include inviting junior and senior undergraduates to participate and co-locating with major discipline-specific research conferences. Recently, most of the DSWs have been co-located with major conferences and have garnered significant financial and logistical support from the conference's sponsoring professional organizations.

2.3 Faculty and Industry Researchers

CRA-W has sponsored Career Mentoring Workshops (CMW) for women since 1994. The workshops are designed with tracks for graduate students in the final stages of their Ph.D. program and who are planning to enter the job market soon, early career new Ph.D.'s, mid-career faculty in associate or recent full professor positions, and industry and government researchers. CRA-W has also organized a CMW version at the SIGCSE (Special Interest Group in Computer Science Education) Conference that focuses on building successful academic careers in primarily undergraduate colleges. These Mentoring Workshops have been so successful that they have been emulated by CRA in a biennial workshop for recent and almost completed Ph.D.'s. Many CS&E departments now routinely send all of their new faculty members to one of these workshops. The CMW program has thus changed the way CS&E departments nurture their new faculty.

3 EVALUATION AND IMPACTS

In 2012, the CRA received grant funding from the NSF to develop an evaluation center, the Center for Evaluating the Research Pipeline (CERP), to provide a unique comparative evaluation methodology called the Data Buddies Project. Data Buddies uses survey research methodology to collect data from a sample of undergraduate and graduate U.S. computing students annually. This yields comparison data for intervention evaluation; that is, Data Buddies allows CERP to survey non-participants within Data Buddy departments and use the same survey instrument to survey program participants. Data Buddies provides large-scale datasets collected via departmental participation every year; for instance, CERP collected data from more than 7,000 undergraduate and nearly 4,000 graduate students in 2017[1]. A significant portion of individuals (>50%) who complete Data Buddies surveys agree to be entered into a database at CERP so that CERP can re-survey those individuals for longitudinal evaluation research. In the following subsections, we provide two examples of how CERP's longitudinal comparative data are used to evaluate CRA-W programs.

CERP also provides formative evaluation (e.g., feedback surveys), short-term impact evaluation (e.g., pre/post test), and qualitative work (i.e., interviews; focus groups) to facilitate program development.

Finally, CERP has recently begun to use contemporary data science techniques for evaluation. For instance, in 2015, CERP used web scraping to observe the career stage of past CMW participants compared to a group of non-participant women [8] We gathered a list of all dissertations that have "Computer Science" in their subject terms using ProQuest, then used the R package "gender" to determine which individuals were women [9]. We then took a random sample of non-CMW participants from that list and ran a script to collect search results for both participants and non-participants. Search results yielded current job titles for each individual, which we then categorized by rank. Using a 3-level categorization of job ranking (entry, mid, senior), we compared CMW participants to the comparison group across academia and industry. We compared all participants to non-participants to get an overall picture of job ranks regardless of their setting. This also allowed us to leverage the larger sample size to increase the power of our statistical analysis. Chi square tests indicated CMW participants were less likely than non-participants to be in an entry level position, $p < .05$, and participants were more likely to be in a senior level position than non-participants, $p < .05$.

3.1 DREU and CREU Impacts

In 2016, CERP examined survey data collected from $N = 523$ computing students graduating from college during 2011 through 2015 [5]. The survey asked students to indicate prior participation in undergraduate research programs (CREU/DREU, Other REU program(s), or No REU) and report plans for the coming year. Using propensity score matching, CERP culled a matched sample of n = 99 students in the three research groups [6]. The matched samples were analyzed in two groups: CREU/DREU vs. Other REU students and CREU/DREU vs. No REU students. Students were compared on (a) whether they were attending graduate school in the upcoming fall and (b) whether they were specifically pursuing a Ph.D. program. Chi square tests indicated the differences between the CREU/DREU students and each of the other comparison groups were significant, $p < .05$. The percentage of students planning to attend graduate school in the fall and the type of degrees they planned to pursue are illustrated in Figure 2. See [5] for the full report.

3.2 Grad Cohort Impacts

In 2017, CERP surveyed women who had either participated in Grad Cohort during 2008-2011 (n = 154) or women and men who had completed a graduate degree during 2008-2011 (n = 21 and n

[1] Data Buddies data are intended to be a community resource. External researchers are encouraged to contact CERP for how to obtain and work with Data Buddies data.

= 133, respectively, [7]. The survey assessed individuals' current status (e.g., job title; professional field). Grad Cohort participants' survey responses were compared against those of women and men non-participants (separately) who had completed their graduate degree during the same timeframe as past Grad Cohort participants. As seen in Table 1, at the time of the survey, the vast majority of Grad Cohort participants and non-participants were working in a computing field. Of particular interest, 64% of Grad Cohort participants were working at a job with a strong research component compared to 43% of non-participant women and 38% of non-participant men. Further, 34% of Grad Cohort participants were working in academia versus 14% of non-participants women and 17% of non-participant men. See [7] for the full report.

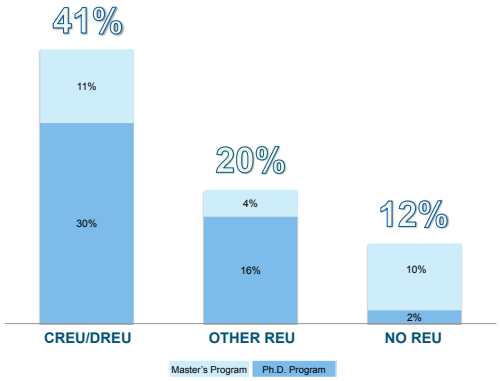

Figure 2: Percentage of students planning to attend graduate school and type of degrees they plan to pursue.

	Grad Cohort	Non-participant Women	Non-participant Men
Do you work in a computing field?			
Yes	96%	100%	99%
No	5%	0%	1%
Does your current job have a strong research component?			
Yes	64%	43%	38%
No	36%	57%	62%
In which setting is your current position?			
Academia	34%	14%	17%
Industry	58%	62%	74%
Government	5%	19%	5%
Other	3%	5%	4%
N	154	21	133
Note. Note. Values represent percentages within each group. Percentages may not equal 100% due to rounding error. Nonparticipant = individuals who had never participated in Grad Cohort. N = number of individuals per group.			

Table 1: Employment Characteristics of Completed Graduate Students

4 CONCLUSIONS

The CRA-W board is currently comprised of about thirty senior women CS&E researchers. All members must be involved in one or more projects. In addition, over a hundred individuals volunteer each year to participate in one of more of CRA-Ws programs. Many of our programs receive funding from government granting organizations, professional societies, as well as from industry, foundations, individuals, and from CS&E departments. Thus, it is truly a community effort working together to solve a community problem.

Since 2004, many of the CRA-W programs have been extended to reach out to underrepresented groups, which in the US primarily includes individuals who self-identify as African-Americans, Hispanics, Native Americans, Pacific Islanders, or individuals with disabilities. As this outreach has grown, the focus of the group has also changed to now address all underrepresented groups in computing. This year, senior male CS&E researchers from underrepresented groups have been invited to become members of the CRA-W board, the board is considering a name change (stay tuned), and, this spring, a Grad Cohort Workshop for Underrepresented Minorities and Individuals with Disabilities is being offered for the first time.

Although diversity in CS&E is a serious concern, we are optimistic that the landscape is changing. The increased interest in interdisciplinary work is opening new research directions, many of which have broad societal impact that tends to attract a more diverse population of researchers. Moreover, there seems to be broad recognition that computing skills are in wide demand and that this demand is only expected to grow over the next several decades. Thus, despite the plethora of negative media depictions of socially inept scientists and computer nerds, computing is starting to be seen as an attractive career with many opportunities. Through their programs, CRA-W is attempting to provide a supportive environment to those in underrepresented groups so that they have the skills needed to succeed and have a sense of community. Of course, time will be the judge.

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