Center for Discrete Mathematics and Theoretical Computer Sciences (DIMACS), Rutgers University

Comparative Evaluation Report of 2009-2012 DIMACS Participants

Prepared by
CRA's Center for Evaluating the Research Pipeline

Jessica L. Cundiff, Ph.D.

Jane G. Stout, Ph.D.

Center for
Evaluating the
Research Pipeline

Recommended citation:
Cundiff, J. L., & Stout, J. G. (2013, August). *Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), Rutgers University: Comparative Evaluation Report of 2009-2012 Participants*. Computing Research Association: Washington, DC. Available from: http://cra.org/cerp/evaluation-reports

To learn more about CRA's Center for Evaluating the Research Pipeline, please visit our website: http://cra.org/cerp. Questions regarding this report and requests for other related documents should be sent to cerp@cra.org.

Center for Evaluating the Research Pipeline
Computing Research Association
1828 L St NW, Suite 800
Washington, DC 20036
p. 202-266-2937
f. 202-667-1066
e. cerp@cra.org

Table of Contents

acknowledgments

We would like to acknowledge and thank the computing students who generously volunteered their time to this research. Their thoughtful responses and comments help us better understand the current experiences of computing students.

We thank all of the partner universities (Data Buddies) for their invaluable cooperation and support. We are incredibly fortunate to work with a number of department chairs and administrative staff who have been instrumental in our ability to collect comparative data.

We also thank the tireless efforts of those who were involved in the initial Data Buddies project: Kenneth Hines, Delicia Mapp, and Ingrid Pufahl for data collection; Erik Russell and Carla Romero for project management; and Betsy Bizot and Joanne Cohoon for evaluation design and leadership.

CERP Steering Committee

Jane Stout, CERP Director, CRA
Betsy Bizot, Director of Evaluation, CRA
Tracy Camp, Professor, Colorado School of Mines
Joanne Cohoon, Associate Professor, University of Virginia
Jerlando Jackson, Professor, University of Wisconsin, Madison
Kathryn McKinley, Principle Researcher, Microsoft Research

CERP Advisory Committee

Jane Stout, CERP Director, CRA
Betsy Bizot, Director of Evaluation, CRA
Joanne Cohoon, Associate Professor, University of Virginia
Rebecca Wright, Professor, DIMACS Director, Rutgers University

The DIMACS REU program is funded by the National Science Foundation (NSF; awards 1004956, 0930134, and 0721113), the Mathematical Association of America, the U.S. Department of Homeland Security (agreement 2009-ST-061-CCI002-02), and other sources.

CERP is currently funded by the National Science Foundation (award 1246649, awarded to CRA). Any opinions, findings, conclusions, and recommendations are the authors' and do not necessarily reflect the views of the funding agencies.

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 men from underrepresented racial/ethnic groups and women of all racial/ethnic backgrounds. 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

DIMACS, the Center for Discrete Mathematics and Theoretical Computer Science headquartered at Rutgers University, aims to prepare students to become the next generation of computer scientists and mathematical scientists. DIMACS uses co-mentored projects, involving graduate students as assistant mentors, and collaborates with other undergraduate research programs that add cultural diversity and an international element. In this way, the DIMACS program focuses on crossing boundaries – between disciplines, between academia and industry, and between nations – to solve problems. This report offers a summary of student outcomes in computing with a specific focus on how participants in DIMACS Research Experiences for Undergraduates compare to other computing students with and without formal research experience (i.e., non-participants).

> ***"The DIMACS community was very welcoming and encouraging. They were very understanding of each student's particular situation. One of the best parts of the experience was the ability to work with a graduate student, who acted as a secondary research adviser. She has been working with me since I left the research program and we have submitted a poster abstract to the 2013 Tapia conference."***
>
> \- DIMACS REU Participant

KEY FINDINGS

Compared to students with other formal research experience, DIMACS participants reported:

- More overall knowledge about graduate school
- Greater impact of research experience on knowledge about graduate school
- Greater impact of research experience on plans to attend graduate school (but no difference in actual enrollment 1-2 years after undergrad)
- More motivation to attain a PhD in computing or math (but no difference in actual enrollment in PhD computing program)
- Greater interest in becoming a college or university professor
- Less interest in a non-research job (and less likely to be working in a non-research job 1-2 years after undergrad)
- Greater usefulness of faculty relationships for current career
- Similar levels of job satisfaction, professional network strength, satisfaction with undergraduate preparedness and usefulness to current career

Results suggest that the DIMACS REU program may fare better than other formal research experiences in terms of preparing students for research careers and for applying to graduate programs in computing and mathematics.

Introduction

Many of the world's most pressing problems are inherently multidisciplinary. They are complex, dynamic, riddled with uncertainty, and potentially massive in scale.

Computer science has a central role to play in addressing these types of challenges by providing tools for analyzing and interpreting massive data sets; models and simulations of complex systems; and designs for future systems that are more efficient and secure.

DIMACS, the Center for Discrete Mathematics and Theoretical Computer Science, headquartered at Rutgers University, is a renowned center at the nexus of computer science, the mathematical sciences, and their many applications. DIMACS aims to prepare students to become the next generation of computer scientists and mathematical scientists, and to develop their capacity to look beyond the confines of these fields for inspiration and impact.

To this end, DIMACS's long-running REU program immerses students in a unique multidisciplinary environment that exposes students to a broad range of computing and mathematical topics, applied in contexts that range from bioinformatics to big data. A particular emphasis of the DIMACS program is on crossing boundaries—between disciplines, between academia and industry, and between nations—to solve problems. Unique features of the DIMACS program include co-mentored projects, involving graduate students as assistant mentors, and combining with other REU programs that add cultural diversity and an international element.

In this report, we compare the experiences and outcomes of students who had participated in the DIMACS REU program to students who had not participated. Our findings are based on survey data collected from two separate time points from separate samples. In the first sample, we administered a survey focused on *career preparation* to continuing students immediately following their summer experiences. In the second sample, we administered a survey focused on *career progression* to students 1-2 years after earning their undergraduate degree.

Students from 2012 DIMACS REU program.

Career Preparation

In this section, we report on outcomes relevant to career preparation among continuing students immediately following their summer experiences.

Method

Procedure. During the fall of 2012, we recruited participants from DIMACS' 2012 summer program, as well as undergraduate students who were pursuing a major or minor in a computing field[1] at colleges and university's across the U.S., to complete CERP's survey of undergraduate experiences in computing (see Table 1 for a list of departments who contributed to this sample). The survey assessed students' past research and professional experiences, with particular emphasis on students' knowledge, confidence, and experience obtained through REU programs. Survey items and scales can be found in Appendix B.

Survey Respondents. To assess the efficacy of the DIMACS REU program through comparative evaluation, we partitioned survey respondents into three comparison groups: those who had participated in the DIMACS REU, those who had other formal research experience, and those with no research experience. We defined formal research experience as summer research experiences completed at students' home institution, another institution, or as part of an internship at a government or industry lab. We do not include less formal experiences such as class-based research projects or independent study in our categorization of formal research experiences, as these experiences are structurally dissimilar to the DIMACS REU program.

Note that the sample sizes of students with no formal research experience (n = 1033) and students with other formal, non-DIMACS research experience (n = 97) are markedly larger than the size of the DIMACS student sample (n = 12). It is analytically inappropriate to compare groups of dramatically different sample sizes because the magnitude of variability in responses within a given sample decreases as sample sizes increase (Myers & Wells, 2003). In order to promote equality of variance across comparison groups, we randomly sampled 30 students from each of our two subgroups of non-DIMACS students for the current report.

Appendix A shows students' academic class standing, gender distribution and racial distribution across the three comparative groups of students. Comparison groups had similar demographic representation with the following exceptions: the DIMACS group had a significantly smaller

[1] We define *computing field* to be any of the following: computer science, computer engineering or electrical and computer engineering, computing information systems, or other computing-related field including fields with a strong computing component such as computational biology or digital media.

Table 1. *Universities that contributed to the fall 2012 sample of undergraduate students.*

CUNY Hunter College	University of Massachusetts, Amherst
DePaul University	University of Michigan, Ann Arbor
George Washington University	University of Michigan, Flint
Georgia Institute of Technology	University of Missouri, Columbia
Kean University	University of Nebraska at Lincoln
Millersville University of Pennsylvania	University of Nevada, Reno
Mills College	University of North Carolina at Chapel Hill
Norfolk State University	University of North Carolina, Charlotte
North Carolina A&T	University of Puget Sound
Old Dominion University	University of Rochester
Pasadena City College	University of South Carolina, Beaufort
Rutgers University	University of South Florida, Main Campus
Saint Joseph's University	University of Texas at Arlington
San Jose State University	University of West Georgia
Sonoma State University	Vanderbilt University
Texas State University, San Marcos	Villanova University
The College of New Jersey	Washington and Lee University
The University of Texas at Dallas	Washington University in St Louis
University of Akron	Western Oregon University
University of California, Los Angeles	Wheaton College (IL)
University of Illinois at Chicago	Yale University
University of Kansas	

Note. Whereas non-DIMACS participants were recruited through one of the departments listed above, DIMACS participants were contacted directly by CERP and not through a department.

proportion of white students than the group with no formal research experience, and a significantly larger proportion of black students than the group with other formal research experience, *p*s ≤ .05.

A Note About the Analyses

The sample size for the comparison group of interest (DIMACS students) is small, rendering the reliability if its outcomes potentially unstable. As such, we urge readers to interpret the following analyses with caution. The current report might be best considered a "pilot study" for a more large-scale investigation of the impact of the DIMACS REU experience on students' academic aspirations and outcomes.

Results

We assessed a variety of outcomes relevant to career preparation for comparative analysis of DIMACS participants versus non-participants. These outcomes focused on students' experience with formal research as well as perceived impact of the formal research experience on factors relevant to career preparation.

REU Satisfaction and Involvement. The top panel of Table 2 shows students' satisfaction with their research experience across three constructs: supervisor's style, team dynamics, and the research experience (see Appendix B for individual items and full scale). DIMACS participants and non-participants who had other formal research experience reported similar satisfaction with team dynamics and the research experience. However, DIMACS participants were less satisfied with their supervisor's style than were non-participants.

The bottom panel of Table 2 indicates students' level of involvement in their research experience. Whereas DIMACS participants and non-participants reported similar levels of involvement in designing the research project, DIMACS participants reported less involvement in making decisions about materials, techniques, and next steps for the research project compared to non-participants.

Table 2. *Formal research experiences: Satisfaction and involvement.*

	DIMACS REU	Other Formal Research
Satisfaction with…		
(1) Very dissatisfied (2) Somewhat dissatisfied (3) Somewhat satisfied (4) Very satisfied		
Supervisor's style	3.10	3.56*
Team dynamics	3.58	3.38
The research experience	3.09	3.40
Responsibility for...		
(1) Someone else was responsible, (2) I shared responsibility, (3) I was primarily responsible		
Designing the research project	1.92	1.96
Deciding what materials/techniques to use	1.75	2.15*
Deciding what to do next	1.45	2.15*

* $p < .05$; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents.

Experience, Knowledge, and Confidence. Students reported on their current level of experience with research activities, knowledge, and confidence in computing (left side of Table 3), as well as their gains in experience, knowledge, and confidence through their formal research experience (right side of Table 3). The scale anchors for each measure are reported directly below Table 3; the full scales and individual items for each measure can be found in Appendix B.

Experience with research activities. We assessed students' experience with research activities across two constructs: *the research process* (e.g., hypotheses generation, experiment design, data collection, analysis) and *dissemination of results* (e.g., presenting and publishing results). Individual items are reported in Appendix B. Students across the three comparison groups reported similar levels of experience with the research process. However, DIMACS participants reported more experience disseminating results compared to students who had not participated in formal research. There were no differences between DIMACS participants and students who had other formal research experience.

Knowledge. We assessed knowledge across two topics: *graduate school* and *computing careers*. Individual items are reported in Appendix B. DIMACS participants reported more knowledge about graduate school as well as greater gains in knowledge about graduate school through their research experience compared to non-participants. DIMACS participants also reported more knowledge about computing careers compared to students who had no formal research experience, but not compared to students who had other formal research experience.

Confidence in computing. We assessed students' confidence in computing with multiple items (individual items are reported in Appendix B). Students in the three comparison groups reported similar levels of confidence.

Table 3. *Reported current level and reported gains from research experience.*

	Current Level			Gained from Research	
	DIMACS REU	Other Formal Research	No Research	DIMACS REU	Other Formal Research
Experience with research activities					
Research process	3.28	3.45	2.94	2.67	2.91
Dissemination of results	2.71	2.73	1.68*	2.71	2.35
Knowledge					
Graduate School	2.71	2.17*	1.78*	3.00	2.13*
Computing Careers	2.98	3.04	2.48*	2.89	2.86
Confidence in computing	3.58	3.45	3.13	3.90	3.91

* $p < .05$; Comparison against DIMACS REU participants.

Note. Values indicate mean within each group. Scale for current level of experience, knowledge, and confidence ranged from (1) *None/Not at all* to (4) *Quite a bit/Very*. Scale for gains in experience and knowledge ranged from (1) *No more than I had* to (4) *Quite a bit more*. Scale for gains in confidence ranged from (1) *Decreased a lot* to (5) *Increased a lot.* See Appendix B for full scales.

Students working on projects during 2012 DIMACS REU program.

Career Interest and Education Goals. We compared the three groups on measures relevant to career interest and education goals. As shown in Tables 4 and 5, DIMACS participants reported greater interest in becoming a college or university professor and were more likely to indicate intentions to pursue a PhD in computing or math compared to non-participants.

Table 4. *Interest in computing careers.*

How interested would you be in having a computing job like the ones below? ***(1) Strongly disinterested (2) Somewhat disinterested (3) Somewhat interested (4) Strongly interested***	DIMACS REU	Other Formal Research	No Research
College/university professor	3.58	2.60*	2.60*
Researcher in industry or government	3.75	3.21	2.97*
High school CS teacher	2.00	2.10	2.31
Non-research position in the computing industry	2.92	3.57*	3.45
Position applying your computing knowledge to another area	3.08	3.59	3.21
Entrepreneur	2.91	2.80	3.13

* $p < .05$; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents.

Table 5. *Education goals.*

What is the highest degree you plan to attain?	DIMACS REU	Other Formal Research	No Research
Bachelor's degree in computing/math	0%	3%	50%*
Master's degree in computing/math	8%	37%	40%
PhD in computing/math	67%	20%*	0%*
Uncertain	0%	30%	3%
Intend highest degree in non-computing/math field	25%	10%	7%

* $p < .05$; Comparison against DIMACS REU participants.
Note. Values represent percentage within each group. Respondents could select only one option.

Additionally, as shown in Table 6, DIMACS participants were more likely to report that their summer experience made it more likely that they would attend graduate school immediately after graduation and less likely that they would pursue a non-research job in computing, compared to students with other formal research experience.

Table 6. *Impact of formal research experience on post-graduation plans.*

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***	DIMACS REU	Other Formal Research
Study computing in graduate school	3.18	3.32
Attend graduate school immediately after undergrad	3.60	2.85*
Earn a master's degree in computing	3.20	3.23
Earn a PhD in computing	3.10	3.04
Get a job in computing, not in research	2.50	3.13*

* $p < .05$; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents.

Student presentations during 2012 DIMACS REU program.

Career Progression

In this section, we report on outcomes relevant to career progression among students 1-2 years after earning their undergraduate degree.

Method

Procedure. During the fall of 2013, we recruited students who had graduated from an undergraduate computing program in 2011 or 2012 to complete CERP's follow-up survey of recent graduates. In particular, we recruited students who had participated in the DIMACS program during the summer of 2009, 2010, or 2011, as well as undergraduate students who had majored or minored in a computing field at one of the universities listed in Table 1. The survey assessed students' current professional status, with particular emphasis on factors relevant to career progression. Survey items and scales can be found in Appendix B.

Survey Respondents. Using the same comparative strategy described in the previous section, we again partitioned survey respondents into three groups: those who had participated in the DIMACS REU (n=34), those who had other formal research experience (n=80), and those with no research experience (n=170).

Students who completed the 2012 DIMACS REU program.

Results

We assessed a variety of outcomes relevant to career progression for comparative analysis of DIMACS participants versus non-participants. These outcomes focused on students' current professional status, network strength, management of work responsibilities and satisfaction, as well as perceived preparation and usefulness of undergraduate experiences on current career progression.

Current Professional Status. As shown in the top panel of Table 7, DIMACS participants were more likely than those with no formal research experience to be enrolled in graduate school, in particular, PhD computing programs as well as non-computing graduate programs. Enrollment in graduate school did not, however, differ between DIMACS participants and students who had other formal research experience, although DIMACS participants were more likely to be enrolled in a non-computing program. Greater enrollment in non-computing graduate programs among DIMACS participants compared to non-participants makes sense due to DIMACS' interdisciplinary focus.

By contrast, as shown in the bottom panels of Table 7, non-participants were more likely to be employed, and to be employed in a non-research position, compared to DIMACS participants. There were no differences in unemployment across the three groups.

Table 7. *Percent of students enrolled in graduate school and/or employed 1-2 years after earning undergraduate degree.*

	DIMACS REU	Other Formal Research	No Research
Total % enrolled in graduate school	***65%***	***40%***	***13%****
Master's computing program	3%	8%	6%
PhD computing program	35%	30%	5%*
Non-computing program	27%	1%*	2%*
Total % employed	***32%***	***61%****	***88%****
Research position	9%	10%	10%
Non-research position	23%	51%*	78%*
Total % unemployed	***6%***	***1%***	***6%***

* $p < .05$; Comparison against DIMACS REU participants.

Note. Values represent percentage within each group. Some respondents indicated that they were enrolled in graduate school as well as employed.

Management of Graduate School. Those who were in graduate school indicated how well they felt they were managing aspects of school (e.g., lab responsibilities) and their personal life (e.g., relationships with family; individual survey items can be found in Appendix B). There were no significant differences between groups (see Table 8). Across all three groups, graduate students on average reported feeling like they were managing their school responsibilities and personal life well, as indicated by means above the midpoint of the scale.

Table 8. *Management of graduate school and personal responsibilities.*

While in graduate school, how well do you feel like you're managing your... ***(1) Very poorly (2) Poorly (3) Neither poor nor well (4) Well (5) Very well***	DIMACS REU (n=22)	Other Formal Research (n=32)	No Research (n=21)
School-related responsibilities	4.19	4.14	4.31
Personal responsibilities/relationships	3.90	3.87	3.94

* p < .05; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents.

Job Satisfaction. Those who were employed indicated their satisfaction with aspects of their job (e.g., opportunities for advancement, freedom to use own judgment, climate of organization; see Appendix B for individual items). Respondents across all three groups reported similar levels of job satisfaction (see Table 9). Specifically, respondents on average reported feeling moderately satisfied with their job, as indicated by means that fell between "slightly satisfied" and "satisfied".

Table 9. *Job satisfaction.*

How satisfied are you with the following aspects of your job? (see Appendix B for items) ***(1) Very dissatisfied (2) Dissatisfied (3) Slightly dissatisfied (4) Neither dissatisfied nor satisfied (5) Slightly satisfied (6) Satisfied (7) Very satisfied***	DIMACS REU (n=11)	Other Formal Research (n=48)	No Research (n=150)
Job satisfaction	5.25	5.65	5.56

* p < .05; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents.

Network Strength and Belonging. We compared the three groups on two measures relevant to respondents' social connectedness in their field: the strength of their professional network and their sense of belonging in their field. As shown in Table 10, respondents across the three groups reported similar network strength and similar levels of belonging.

Table 10. *Strength of professional network and sense of belonging.*

	DIMACS REU	Other Formal Research	No Research
Strength of professional network *(1) Very weak (2) Somewhat weak (3) Neither weak nor strong (4) Somewhat strong (5) Very strong*	3.09	3.05	2.86
Sense of belonging *(1) Strongly disagree - (7) Strongly agree*	4.38	4.44	4.50

* p < .05; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents. Sense of belonging was measured across 7 items; higher numbers indicate greater sense of belonging. See Appendix B for individual items and full scale for the belonging measure.

Evaluation of Undergraduate Experiences. Survey respondents evaluated their undergraduate experiences on two aspects: preparedness and usefulness.

Preparedness. Overall, respondents across the three comparison groups were similarly satisfied with their undergraduate preparation; however, differences emerged on specific aspects. As shown in Table 11, non-participants were more satisfied with their preparation of general knowledge about the computing field compared to DIMACS participants. By contrast, DIMACS participants were more satisfied with their preparation in research skills and experience compared to those who had no formal research experience, but not compared to those who had other formal research experience.

Usefulness. Overall, DIMACS participants perceived their undergraduate career as more useful compared to non-participants with no formal research experience. In particular, as shown in Table 12, DIMACS participants found their research skills and experience, as well as their relationships with graduate students and postdocs, as more useful than did non-participants who had no formal research experience. Moreover, DIMACS participants found their relationships with faculty as more useful compared to non-participants.

Table 11. *Satisfaction with undergraduate preparation.*

How satisfied are you with how well your undergraduate career prepared you in the following areas? ***(1) Very dissatisfied (2) Dissatisfied (3) Slightly dissatisfied (4) Neither dissatisfied nor satisfied (5) Slightly satisfied (6) Satisfied (7) Very satisfied***	DIMACS REU	Other Formal Research	No Research
Specific technical knowledge	5.41	5.47	5.08
General knowledge about the computing field	5.31	6.24*	5.95*
Collaboration skills	5.44	5.75	5.64
Research skills and experience	5.59	5.96	4.92*
Mean score across all 4 items	***5.43***	***5.85***	***5.40***

* $p < .05$; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents.

Table 12. *Usefulness of undergraduate experiences.*

How useful are you finding the following aspects of your undergraduate career? ***(1) Not at all useful (2) Slightly useful (3) Moderately useful (4) Quite a bit useful (5) Extremely useful***	DIMACS REU	Other Formal Research	No Research
Specific technical knowledge	3.97	3.68	3.69
General knowledge about the computing field	3.69	4.01	4.05
Collaboration skills	3.88	4.30	3.88
Research skills and experience	4.12	3.83	3.20*
Relationships developed with faculty	3.64	2.95*	2.36*
Relationships developed with grad students and postdocs	2.79	2.62	2.07*
Relationships developed with other undergrad students	3.15	3.33	2.92
Mean score across all 7 items	***3.63***	***3.58***	***3.22****

* $p < .05$; Comparison against DIMACS REU participants.
Note. Values indicate mean score across respondents.

Summary and Conclusion

The general findings from this report indicate that the DIMACS REU program enhances students' interest in and preparation for applying to graduate school compared to students who have non-DIMACS formal research experiences. In addition, results indicate that DIMACS participants are more likely to actually enroll in non-computing graduate programs compared to non-participants, reflecting the interdisciplinary focus of the DIMACS REU program. Results also suggest that DIMACS participants are more likely to pursue research career trajectories compared to non-participants. Keeping in mind the limitations of the small sample sizes in this report, the current findings provide initial evidence that the DIMACS REU program may help promote students' persistence in research careers.

DIMACS 2012 REU student and his mentors.

Future research should assess whether and how DIMACS's interdisciplinary focus benefits students. For example, one line of research might assess whether DIMACS's REU structure that promotes exposure to a diversity of viewpoints in different fields and/or cultures enhances students' creativity and problem solving strategies. If this were the case, the DIMACS REU program would serve as a valuable tool for increasing innovation in future generations of the computing workforce.

References

Myers, J. L., & Well, A. D. (2003). *Research design and statistical analysis.* Lawrence Erlbaum Associates, Publishers, Mahwah, N.J.

Appendix A: Sample Characteristics

Career Preparation Survey Sample

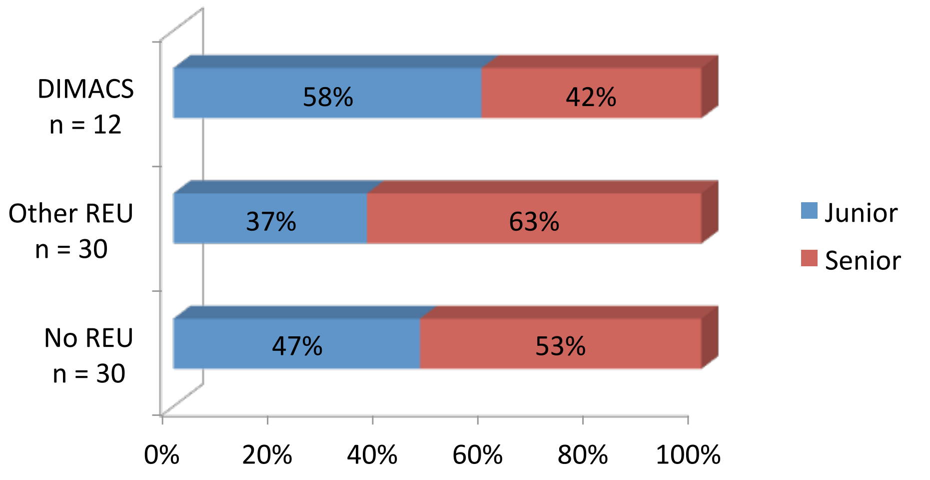

Figure 1. *Academic class standing of respondents within each comparison group of the career preparation survey sample.*

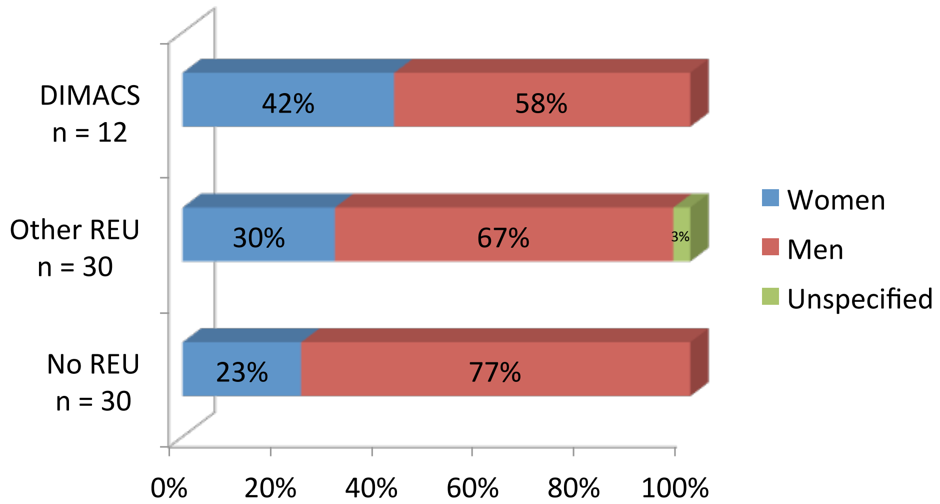

Figure 2. *Gender distribution of respondents within each comparison group of the career preparation survey sample.*

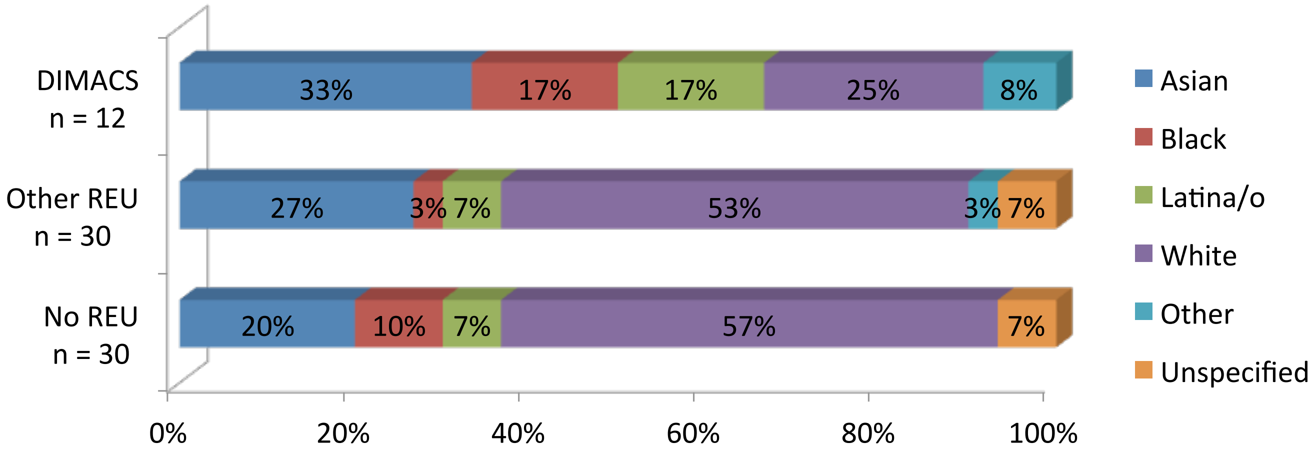

Figure 3. *Racial/ethnic distribution of respondents within each comparison group of the career preparation survey sample.*

Career Progression Survey Sample

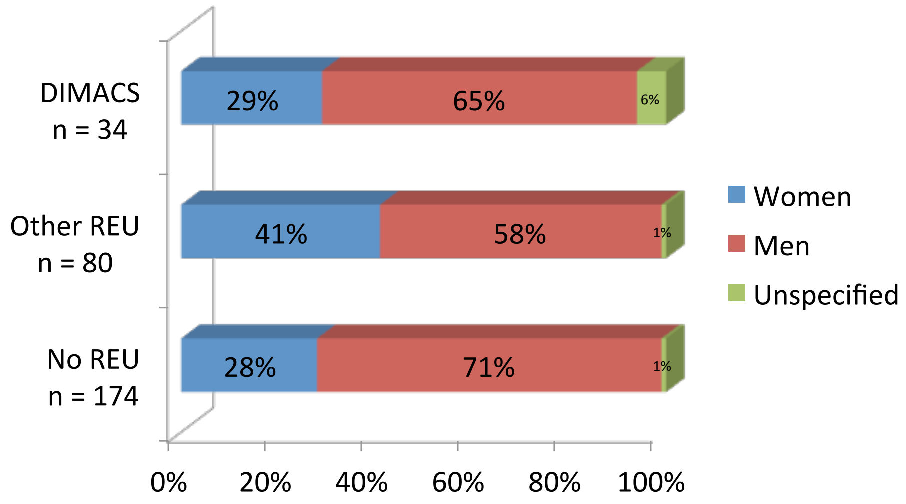

Figure 2. *Gender distribution of respondents within each comparison group of the career progression survey sample.*

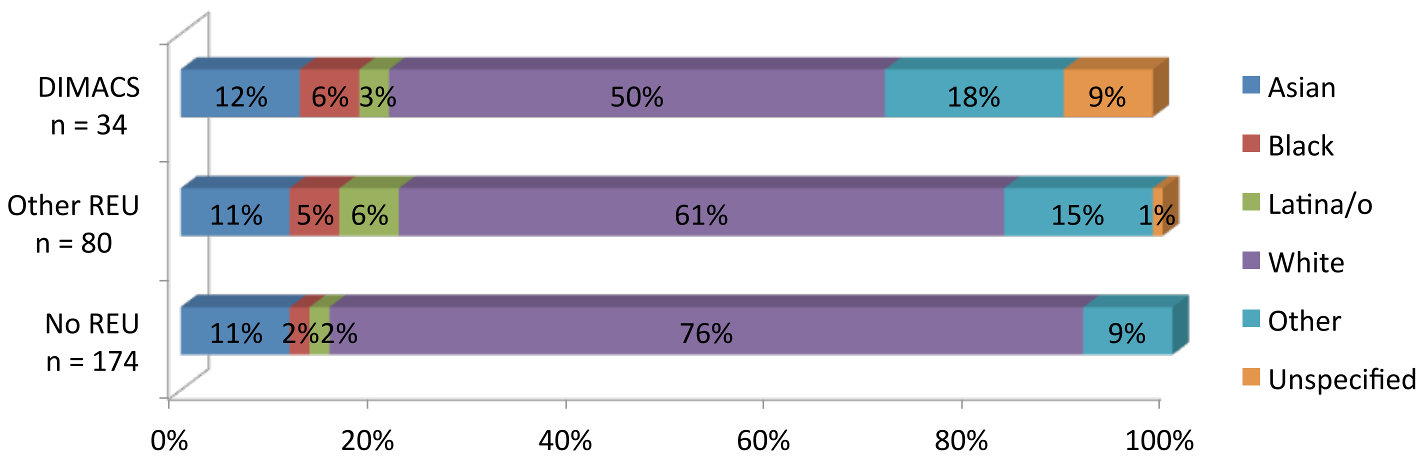

Figure 3. *Racial/ethnic distribution of respondents within each comparison group of the career progression survey sample.*

Appendix B: Aggregate Survey Items

Individual items for multi-item measures are presented below. When using multi-item measures, is important to assess whether all items in the measure are measuring the same underlying construct (i.e., reliability). A conventional index of reliability is Cronbach's alpha (α), where higher values indicate greater reliability. Alpha levels ≥ .70 are considered acceptable. We report Cronbach's alpha levels for each multi-item measure that follows.

Career Preparation Survey

Satisfaction with Summer Research Experience. We assessed students' satisfaction with their summer research experience across three constructs: supervisor's style (5 items), team dynamics of the research group (3 items), and the research experience (9 items). 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

Experience with Research Activities. We assessed students' current experience and gained experience across two constructs: the research process (6 items) and dissemination of results (4 items). Items for each construct were averaged together to form composite scores. Individual items are listed below.

Current experience. How much experience do you have with the following research activities:

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

Research process (α = .89)

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

Dissemination of results (α = .88)

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

Gained experience. 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

Research process (α = .86)

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

Dissemination of results (α = .86)

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

Knowledge. We assessed students' current knowledge and gained knowledge across two constructs: graduate school (6 items) and computing careers (4 items). Items for each construct were averaged together to form composite scores. Individual items are listed below.

Current knowledge. How knowledgeable are you about the following topics?

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

Graduate school ($\alpha = .77$)

- What it is like to be a graduate student in computing
- How to get financial support for graduate school
- How to select the right graduate program for you
- Criteria for admission to graduate programs

Computing careers ($\alpha = .64$)

- How computing can make a positive contribution to society
- What it is like to work as a computer scientist or computer engineer
- How to get the kind of job you would like to have after graduation
- What it is like to do computing research

Gained knowledge. 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*

Graduate school ($\alpha = .84$)

- What it is like to be a graduate student in computing
- How to get financial support for graduate school
- How to select the right graduate program for you
- Criteria for admission to graduate programs

Computing careers ($\alpha = .84$)

- How computing can make a positive contribution to society
- What it is like to work as a computer scientist or computer engineer
- How to get the kind of job you would like to have after graduation
- What it is like to do computing research
- How to work independently
- How to work collaboratively
- What career options are available within computing

Confidence. We assessed students' current confidence with 7 items (α = .86) and gained confidence with 6 items (α = .92). Items were averaged together to form composite scores. Individual items are listed below.

Current confidence. How confident are you that, if you want to, you can successfully...

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

- Contributing to a research project in computing
- Earn a B or better grade in all your computing courses
- Complete your undergraduate degree in computing
- Get admitted to a graduate school in computing, if you choose
- Complete a graduate degree in computing
- Become a capable researcher in computing
- Have a successful career in computing

Gained confidence. What affect, if any, did your summer research experience have on your confidence that you can successfully...

(1) Decreased a lot *(2) Decreased a little* *(3) Unchanged*
(4) Increased a little *(5) Increased a lot*

- Contributing to a research project in computing
- Complete your undergraduate degree in computing
- Get admitted to a graduate school in computing, if you choose
- Complete a graduate degree in computing
- Become a capable researcher in computing
- Have a successful career in computing

Career Progression Survey

Management of Graduate School. We assessed current graduate students' management of their school-related responsibilities (5 items) and personal responsibilties (3 items). Items for each construct were averaged together to form composite scores. Individual items are listed below.

While in graduate school, how well do you feel you are managing your...

(1) Very poorly (2) Poorly (3) Neither poor nor well (4) Well (5) Very well

School-related responsibilities (α = .82)

- Coursework
- Lab responsibilities
- Teaching assistantship responsibilities
- Research responsibilities
- Relationship with your advisor

Personal responsibilties/relationships (α = .83)

- Activities outside of school
- Relationships with friends
- Relationships with family

Job Satisfaction. We assessed the job satisfaction of those who are currently employed with 16 items that were averaged together to form a composite score ($\alpha = .93$). Individual items are listed below.

How satisfied are you with the following aspects of your job?

(1) Very dissatisfied *(2) Dissatisfied* *(3) Neither dissatisfied nor satisfied*
(4) Satisfied *(5) Very satisfied*

- Feeling like my work can help society
- Feeling interested in my work
- The chance to do something that makes use of my abilities
- My pay for the amount of effort I put into my work
- Workload
- Opportunities for advancement
- Opportunities for training and professional development
- The freedom to use my own judgment
- The opportunity to try my own methods
- The praise I get for doing a good job
- The feeling of accomplishment I get from my work
- The amount of travel required
- The accommodation or flexibility provided to manage multiple life roles
- Feeling like my contributions are valued and recognized by my organization
- Clarity of work requests and expectations
- The climate of the organization

Belonging. We assessed sense of belonging with 7 items that were averaged together to form a composite score (α = .89). Individual items are listed below.

If I were to attend a professional conference in my field, I would feel...

(1) Strongly disagree (2) Disagree (3) Slightly disagree (4) Neither disagree nor agree
(5) Slightly Agree (6) Agree (7) Strongly agree

- A sense of belonging
- Uncomfortable (reverse-scored)
- Welcomed
- At ease
- Anxious (reverse-scored)
- Like I fit in
- Nervous (reverse-scored)