Programming Languages Mentoring Workshop (PLMW) Evaluation Report

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Evaluation

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CRA-W
Computing Research Association
Women

CRA
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the coalition
to diversify computing

About CERP

The Computing Research Association's (CRA) Center for Evaluating the Research Pipeline (CERP) evaluates the effectiveness of intervention programs designed to increase retention of individuals 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, subjective experiences, persistence, and success among individuals involved in academic programs and careers related to computing. For more information about CERP, visit http://cra.org/cerp/.

Executive Summary

Compared to a group of students who had never participated in a mentorship workshop, Programming Language Mentorship Workshop (PLMW) participants reported:

- A stronger computing identity
- More interest in academic research and teaching careers

PLMW participants and non-PLMW participants reported equivalent levels of:

- Knowledge about professional development strategies
- Confidence in one's ability to become a successful computing professional
- Perceived support from a mentor
- Sense of belonging in computing

Introduction

The Programming Language Mentoring Workshop (PLMW) has been organized in conjunction with the annual Principles of Programming Languages (POPL) conference since 2012. In 2015, it was also held in conjunction with the International Conference on Functional Programming (ICFP) and is scheduled to take place as part of ICFP 2016 as well. The workshop targets Master's and Ph.D. students as well as advanced undergraduates. Its goal is "to introduce newcomers (mainly young Ph.D. students, along with some M.S. and undergraduate students) to the field of programming language theory and formal verification, with a particular emphasis on women and under-represented minorities." [1]

During the daylong workshop, typically held prior to the start of the associated conference, students get a chance to attend technical sessions on programming languages, and experience professional mentoring. This allows students to not only get a glimpse of the current state of the field but also receive some career advice as they begin to build their professional persona. The organizers of the workshop explicitly seek to provide students with opportunities to network with their peers as well as the speakers of the workshop.

In this report, we examine the degree to which the PLMW is meeting its goals using survey data collected from computing[1] students at over 100 universities during the Fall 2015 semester. The large-scale survey data enable us to compare PLMW students to students who have not participated in a PLMW. Further, we implement an analytic technique that generates a comparison group of non-PLMW students that are "matched" on a number of background variables (e.g., gender, academic year in program; see Survey Respondents section for details).

Method

Procedure

Every year, the CRA's Center for Evaluating the Research Pipeline (CERP) collects survey data from U.S. undergraduate and graduate students who are completing computing degree programs or enrolled in computing courses. The survey assesses students' past professional development experiences (e.g., participation in a career mentoring workshop), subjective experiences in the computing community (e.g., sense of belonging in computing), and aspirations for the future (e.g., interest in becoming a college/university computing professor). Survey items and scales can be found in Appendix A. In the fall of 2015, CERP collected data from 9,318 undergraduate students, and 2,714 graduate students. Of those students, 47 were past PLMW students (7 undergraduate and 40 graduate students).

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[1] Our definition of computing includes any of the following fields: 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.

Survey Respondents

To assess the impact of the PLMW program on students' subjective experiences in the computing community and their career aspirations, we utilized a comparative evaluation framework. For this, we first extracted students who had no prior experience participating in a career-mentoring workshop from our sample of non-PLMW students. Among this group of students, we further extracted a subsample that is comparable to the 47 past PLMW participants in our sample using *propensity score matching*. Propensity score matching is an analytic technique that "matches" individuals in a treatment group (e.g., PLMW) to individuals from a comparison group (e.g., students who did not participate in a program similar to the PLMW) who are as comparable as possible on a set of relevant individual-level characteristics [2,4]. Thus, propensity score matching controls for the role of student-level variables (e.g., year in degree program) that might otherwise explain outcome variables (e.g., confidence) rather than the "treatment".

Non-PLMW students were matched to PLMW students on whether they were part of an underrepresented group in computing (i.e., women; men of color), citizenship status (i.e., U.S. vs. non-U.S. citizen), age, and year in program. See Appendix B for the matched PLMW versus comparison group demographics. PLMW participants and non-participants were also matched on their home institution's level of research productivity [3]. In the resulting sample, 85% of PLMW participants and 91% of non-PLMW participants were enrolled at institutions with very high research productivity.

Research Design

Once the PLMW students (n = 47) were matched with a comparable group (n = 47), the complete sample for comparative analysis consisted of 94 observations. PLMW and non-PLMW participants who were graduate students were compared on the following factors: level of interest in a list of career options, self-reported knowledge of professional development strategies, and confidence in one's ability to become a successful professional. Undergraduate and graduate PLMW vs. non-PLMW participants were compared on their computing identity, level of support they receive from their mentors, and sense of belonging in the computing community.

A Note About the Analyses

While propensity score matching is a powerful analytic technique, it does not guarantee plausibility of making causal claims. The data reported on here were collected at a single point in time, after the PLMW workshops occurred. Thus, any differences between PLMW vs. non-PLMW participants reported on here should be interpreted with caution.

Results

In this section, we present our findings organized by survey topic. Likert style items were measured using a 5-point Likert scale with higher values indicating great levels of agreement/interest/knowledge; a score of 3 reflects a neutral/indifferent response. We used independent samples t-tests to conduct statistical mean comparisons for Likert style items. Further, we used a two-tailed test with a cut-off alpha criterion of $p \leq .05$, to determine statistical significance for each analysis.

Computing Identity, Mentor Support, and Sense of Belonging

Table 1 shows that PLMW students identified more strongly with computing than non-PLMW students (e.g., "Computing is a big part of who I am"), $t(91)= 2.24$, $p = .03$. However, we found no group differences in either perceived mentor support or sense of belonging in the computing community.

Table 1. Computing Identity, Mentor Support, and Sense of Belonging

Scale anchors ranged from (1) Low to (5) High.	PLMW	Non-PLMW
Computing identity	4.34*	4.02
Mentor support	3.48	3.63
Belonging	3.99	3.89

Note: Values indicate mean score within each group.
*$p \leq .05$. n = 93 for computing identity and belonging with computing; n = 94 for mentor support.

Graduate Students' Career Interests

In Table 2, we see PLMW participants reported greater interest than non-PLMW participants in pursuing the following careers: tenured faculty at a research university, $t(78)= 3.32$, $p < .01$, tenured faculty at a teaching college, $t(78) = 3.55$, $p < .01$, non-tenured computing researcher at a university, $t(77)= 3.91$, $p < .01$, and non-tenured faculty at a teaching college, $t(78) = 3.55$, $p < .01$. Furthermore, despite both groups reporting low interested in becoming a middle/high school computing teacher, PLMW students were more interested in these positions than non-PLMW participants, $t(78)= 2.00$, $p = .05$. Note computing research in industry was of greatest interest to both groups of students.

Table 2. Graduate students' career interests

Scale anchors ranged from (1) Very uninterested to (5) Very interested	PLMW	Non-PLMW
Tenured faculty in a computing department at a research university	4.05*	3.02
Tenured faculty in a computing department at a teaching college	3.33*	2.27
Non-tenured computing researcher at a university	3.10*	2.03
Non-tenured computing teaching faculty at a college/university	2.65*	1.73
Computing researcher in industry	4.35	4.22
Computing researcher in a government lab	3.90	3.42
Non-research position in industry	3.13	3.10
Non-research position in a government lab	2.48	2.35
Middle/high school computing teacher	2.10*	1.60
Entrepreneur (computing related)	3.33	3.50
Non-computing career	1.82	2.08

Note: Values indicate mean score within each group.
* $p \leq .05$. n = 80 for all items except (a) non-tenured computing researcher at a university and (b) non-research position in industry, n =79.

Graduate Students' Professional Development Strategies

As seen in Table 3, PLMW and non-PLMW graduate students did not differ in self-reported professional development strategies. Overall, professional development strategies hovered around the midpoint of the scale. Students tended to have particularly low knowledge about negotiating job offers, and how to obtain research funding.

Table 3. Professional development strategies

How would you rate your knowledge of each of the following? (1) Very poor to (5) Very strong	PLMW	Non-PLMW
Preparing my curriculum vitae	3.30	3.55
Resume writing	3.50	3.58
Job search strategies	2.85	3.10
Negotiating job offers	2.27	2.55
Effective teaching	3.52	3.45
Obtaining funding for research	2.50	2.45
Time management strategies	3.12	3.23
How to balance my career and social life	3.30	3.02

Note: Values indicate mean score within each group.
* $p \leq .05$. n = 80 for all items except for resume writing, n = 78.

Graduate Students' Confidence

As seen in Table 4, PLMW and non-PLMW graduate students did not differ in confidence in becoming a successful computing profession. On average, students in both groups reported confidence levels above neutral, and were least confident about discussing theory with senior members of their field.

Table 4. Graduate students' confidence

I am confident that I can… (1) Strongly disagree to (5) Strongly agree	PLMW	Non-PLMW
Become an expert in my field	4.03	4.25
Complete my department's milestones towards earning my degree in a timely manner	4.30	4.17
Publish in top journals in my field	3.98	3.92
Discuss theory with senior members of my field	3.80	3.62
Articulate thoughtful answers to theoretical questions about my work during a presentation	3.90	4.03

Note: Values indicate mean score within each group.
* $p \leq .05$. n = 80 for all items.

Conclusion

Past PLMW participants were compared to a propensity score matched group of students with no mentoring workshop experience. This method of evaluation allowed us to mimic an experimental design and examine potential effects of a treatment, in this case participation in the PLMW workshop. Our results suggest that participation in a PLMW is associated with developing a stronger "computing identity", and greater interest in academic research and teaching careers.

However, past PLMW students showed no observable difference from non-PLMW students in their knowledge about professional development strategies, confidence in becoming a successful computing professional, perceived mentor support, and sense of belonging in the computing community. Given that the goals of the PLMW include promoting career knowledge through mentorship, these null findings may seem surprising. It is possible the CERP instrument did not capture the essence of the PLMW experience. Future evaluation strategies should generate targeted survey items that directly map onto the goals of the PLMW. It is also possible that PLMWs are too brief in duration to meet the organizers' knowledge building and mentorship goals. Future iterations of the PLMW might extend the PLMW duration, or encourage students to attend the PLMW more than once (i.e., multiple dosages), in order to enhance the impact of PLMWs on students' professional development and sense of mentor support. Despite these null findings, the data for students in this sample provide important information for understanding the goals, perceptions, and beliefs of students in general (e.g., difference in confidence levels across a range of topics).

Although the PLMW is particularly interested in enhancing success among underrepresented students, small sample sizes precluded our ability to evaluate this population of students' data (among PLMW participants in our sample, 5 undergraduate and 10 graduate students were members of an underrepresented group in computing). PLMW organizers might benefit from collaborating with other organizations with strong outreach to underrepresented students (e.g., the CRA's Committee on the Status of Women in Computing Research, CRA-W; the Coalition to Diversity Computing, CDC), in order to recruit more underrepresented PLMW participants. Higher numbers of underrepresented PLMW participants would likely increase the number of underrepresented students who take part in evaluation activities, allowing for rigorous evaluation of the PLMW on underrepresented students in particular

References

1. *ACM SIGPLAN*. (2015). PLMW 2015. Retrieved April 7, 2016, from http://plmw15.iisc-seal.net/

2. *Bai, H*. (2015). Current issues on propensity score matching: Matching with/without replacement, common support, and sample ratio. In W. Pan, & H. Bai (Eds.), *Propensity score analysis: Fundamentals, developments and extensions*. New York, NY: Guilford Press.

3. *Carnegie Foundation for the Advancement of Teaching* (2015). The Carnegie Classification of Institutions of Higher Education, 2010 edition, Stanford, CA.

4. *Shadish, W. R., Cook, T. D., & Campbell, D. T.* (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton Mifflin.

Appendix A

Our measures included single survey items as well as constructs that combine multiple survey items into a single measure. We determined reliability for multi-item constructs using Cronbach's alpha (α). Alpha levels ≥ .70 are considered acceptable. Below are all the survey items used this report.

Identification with computing construct, α = 0.70

How much do you agree or disagree with the following statements?

- I see myself as a "computing person."
- Computing is a big part of who I am.
- I am interested in learning more about what I can do with computing.
- Using computers to solve problems is interesting.

Strongly Disagree (1)	Somewhat Disagree (2)	Neither Agree nor Disagree (3)	Somewhat Agree (4)	Strongly Agree (5)

Mentor support construct, α = 0.87

To what extent do you have a mentor who....

- Shows compassion for concerns and feelings you discussed with them?
- Shares personal experiences as an alternative perspective to your problems?

Not at All (1)	A Little (2)	Somewhat (3)	Quite a Bit (4)	Very much (5)

Belonging construct, α = 0.80

How much do you agree or disagree with the following statements?

- I feel like I "belong" in computing.
- I feel like an outsider in the computing community. (reverse coded)
- I feel welcomed in the computing community.

Strongly Disagree (1)	Somewhat Disagree (2)	Neither Agree nor Disagree (3)	Somewhat Agree (4)	Strongly Agree (5)

Career interests, individual items

How interested are you in the following types of careers?

- Tenured faculty in a computing department at a research university
- Tenured faculty in a computing department at a teaching college
- Non-tenured computing researcher at a university
- Non-tenured computing teaching faculty at a college/university
- Computing researcher in industry
- Computing researcher in a government lab
- Non-research position in industry
- Non-research position in a government lab
- Entrepreneur (computing related)
- Middle/high school computing teacher
- Non-computing career

Very Uninterested (1)	Somewhat Uninterested (2)	Neither Uninterested nor Interested (3)	Somewhat Interested (4)	Very Interested (5)

Career related knowledge, individual items

How would you rate your knowledge of each of the following, from very poor to very strong?

- Preparing my curriculum vitae
- Resume writing
- Job search strategies
- Negotiating job offers
- Effective teaching
- Obtaining funding for research
- Time management strategies
- How to balance my career and social life

Very poor (1)	Below average (2)	Average (3)	Above average (4)	Very strong (5)

Confidence, individual items

How much do you agree or disagree with the following statements? I am confident that I can...

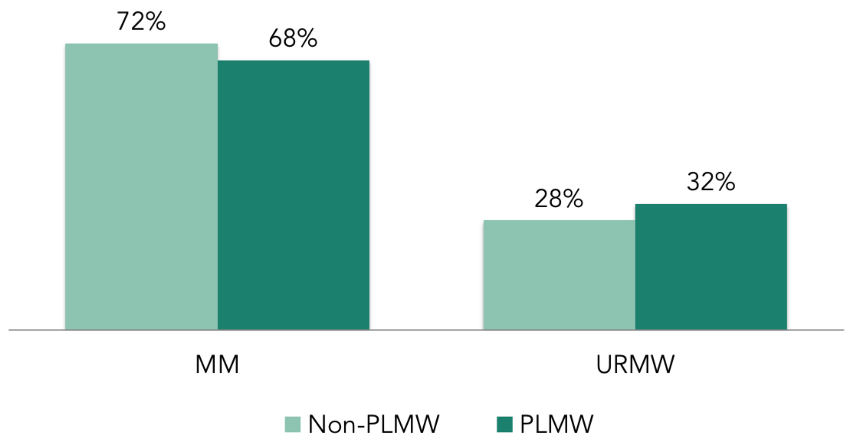
- Become an expert in my field
- Complete my department's milestones towards earning my degree in a timely manner
- Publish in top journals in my field
- Discuss theory with senior members of my field
- Articulate thoughtful answers to theoretical questions about my work during a presentation

Strongly Disagree (1)	Somewhat Disagree (2)	Neither Agree nor Disagree (3)	Somewhat Agree (4)	Strongly Agree (5)

Appendix B

Distributions of underrepresented group status in computing (i.e., women; men of color), citizenship status (i.e.,U.S. vs. non-U.S. citizen), age, year in program, and type of degree program (i.e., undergraduate versus graduate) for PLMW participants (n=47) and non-PLMW students (i.e., matched sample of students without a similar workshop experience, n=47)

Figure 1. Underrepresented Status in Computing by Student Group



Note. MM = Asian and White men. URMW = Underrepresented men, and all women.

Figure 2. Citizenship Status by Student Group

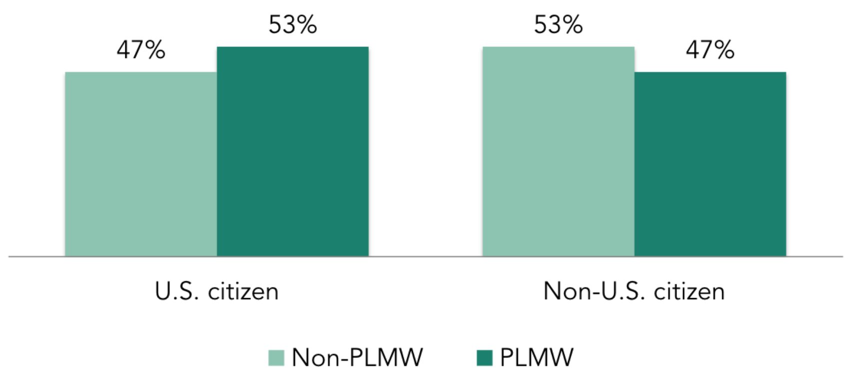


Figure 3. Age by Student Group

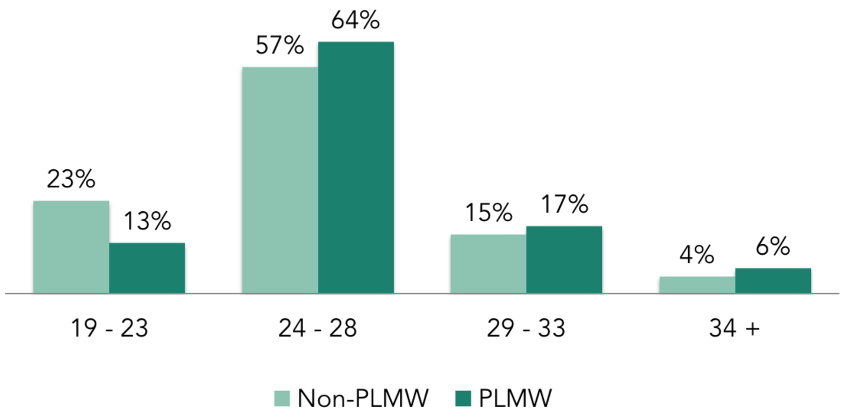


Table Appendix B-1. Median Year in Degree Program by Degree Level by Student Group

	PLMW	Non-PLMW
Undergraduate students' academic year	4th year	4th year
M.S. students' anticipated years until graduation	1.5 years	1.5 years
Ph.D. students anticipated years until graduation	4 years	4 years