Now what?
Action items from social science research to bridge the gender gap in computing research

Jane Stout
Computing Research Association
1828 L St NW, Suite 800
Washington DC, 20036
202.266.2937
jane@cra.org

Tracy Camp
Department of EECS
Colorado School of Mines
Golden, Colorado
+1 303-384-2184
tcamp@mines.edu

ABSTRACT
Our culture is currently paying a great deal of attention to issues of diversity in computing and technology. More specifically, society wonders why there are not more women involved in computing. Statistics on women's representation in all levels of the postsecondary academic pipeline, and in professions outside of the academy, have been bleak for decades. In response to this, social scientists have taken great interest in understanding why this cultural phenomenon exists. Although women's underrepresentation may seem intractable due to many years of stagnancy, we urge readers to take heart, and capitalize on the cultural climate, which places great emphasis on promoting gender equity and diversity in computing.

In this article, we review a number of factors that explain women's low participation in and attrition from computing, which have been developed through empirical research. We then articulate actionable items that can be implemented "on the ground" in classrooms and professional settings, as well as "on the books" at the administrative and public policy level. We conclude by urging readers to consider this a "people's issue" rather than a "women's issue", because all people can benefit from environments, cultural beliefs and policies that espouse inclusivity and equity.

Categories and Subject Descriptors
K. Computing Milieux

K.4 COMPUTERS AND SOCIETY

K.4.2 Social Issues

General Terms
Human Factors

Keywords
Gender diversity; Action items; Social science research

1. INTRODUCTION
It is no secret that computing suffers from a gender diversity problem. Evidence of women's low participation in computing is commonplace in mainstream media outlets, social science research journals and major, national data sources such as the CRA's annual Taulbee Survey report [1] and the National Science Foundation's diversity statistics in science, technology, engineering and mathematics (STEM) fields [2]. Arguments for the importance of gender diversity come in at least two flavors. One is a humanitarian standpoint, where all individuals should have the opportunity to be aware of and express interest in a wide range of financially lucrative and personally rewarding professions. A second argument for gender diversity is more capitalistic, such that relying primarily on half of the population (i.e., men) to develop the computing labor force is unsustainable and lacking in innovative potential due to a relatively homogenous set of experiences and perspectives. We concur that gender diversity in computing is important for a number of reasons, and present a synthesis of social science research which explains why women tend to shy away from computing. Importantly, we also articulate ways in which these findings can inform interventions, strategies, and structural change to narrow the gender gap.

2. COMPUTING HAS AN IMAGE PROBLEM

2.1 Social Relevance
As young people start to think about the types of career they might like to pursue in adulthood, one strong determinant of career interest is how well a given career aligns with one's personal goals and values. A great deal of research indicates that women and men tend to differ on an important career value, which is a desire for one's work to have clear social applications (i.e., ability to serve humanity and/or solve social problems; [3,4]). This is not to say that men do not also value work with social applications; rather, women as a group simply tend to value it more. Thus, one reason women tend to shy away from a computing-related career is because people, in general, tend to view STEM fields (including computing) as having low relevance to the real world [5].

Computing professionals know, however, that our culture's view of computing as inapplicable to the real world is inaccurate. In fact, computing touches nearly every part of our lives today, from the cars we drive, to the movies we watch, to the way we do

business. For example, a car developed today is likely to have 50 microprocessors in it to assist with tasks associated with diagnostics, safety, and comfort; each of these tiny computers need dedicated software to do their job. Computing also drives innovation in the sciences, e.g., from helping understand global warming to developing a cure for the Ebola virus. To solve the world's most challenging real-world problems require a diverse workforce trained in computing. In fact, the failure to create diverse teams (e.g., teams with both men and women) is a huge opportunity cost to future technical innovations.

Action items

What can be done to allay young peoples' (and especially young girls') misconception of computing? We encourage professionals in the computing community to forge collaborative relationships with the K-12 system, with a goal to make computing applications concrete and engaging. This effort could involve bringing young people into research labs for demonstrations or professionals entering the classroom to give an age-appropriate presentation. In either case, the goal is to make clear what computing work looks like, its applications to society and, most importantly, what computing professionals look like. It is very important to ensure that at least 50% of the demonstrators are *women*, and that women and men alike are racially/ethnically *diverse*. Specifically, research shows that students' engagement, and confidence increases significantly if they see role models with whom they can personally identify [6].

2.2 A "geeky guy thing"

Another big reason girls and women avoid computing is due to its stereotype of being a "guy thing" and "nerdy". It is, therefore, not surprising that many people, and especially women, avoid a computing career track; not surprising, most women find it difficult to identify with being "a guy" and being nerdy has a negative connotation in our culture. Indeed, research indicates the general public expects the typical computer science lab to be brimming with stereotypically "geeky" décor (science fiction posters and memorabilia, junk food, video games, etc.) [7]. Importantly, exposing undergraduate women who are not computer science majors to computer science environments full of geeky paraphernalia makes women feel as though they do not "fit" in those settings, which, in turn, decreases their interest in pursuing computer science as a major [7]. Other research suggests that women role models in computing help boost women's perceived ability to succeed in computing, but those role models have a deflating effect on perceived ability if those role models are perceived as a stereotypical computer scientist (i.e., geeky) [8].

Action items

The takeaway from this research is that women tend to be repelled by negative stereotypes associated with computing. That is, the physical computing environment may tend to default to an ambient "geeky guy" vibe, which may make it difficult for women to feel comfortable and confident in computing settings. It is easy enough to make slight modifications to the environment so that it is more gender-neutral; in the case of the geeky computer science setting described previously, one could replace science fiction memorabilia with images that a general audience can identify with, such as art or nature memorabilia, signaling an inclusive environment for everyone. In a similar vein, other research suggests that small changes in the language people use to refer to people involved in computing (e.g., using "him or her" in place of "him" or "guys"), can make women feel included and motivated to engage [9]. In sum, computing environments and discourse should strive to eliminate subtle signals that a specific pedigree of individuals "belongs" in computing.

3. WOMEN FEEL LIKE THEY DON'T "BELONG"

For decades, social scientists have found that people have a core need to feel welcomed, appreciated and accepted (i.e., "belonging") in social spaces in order to experience psychological well-being [10]. When students do not feel that they belong in an academic setting, they become disengaged and unmotivated, resulting in low academic performance [11]. This fact is important, because research indicates that women have the sense that they belong in computing less than men do [12]. This research also indicates that, feeling a secure sense of belonging is *particularly important for women*; that is, women more than men rely on belonging to feel engaged in their computing career track [12].

A strong predictor of feeling a low sense of belonging is noticing that there are very few other people who are "like you" in the social environment [13]. Thus, to the extent that women are constantly and overwhelmingly outnumbered by men in computing, it is no surprise women tend to feel that they do not fit in computing. As a case in point, at all levels of the academic computing pipeline, men outnumber women by at least 3:1 [2]. This means that not only are women trainees' peers primarily men, but their potential mentors and role models (i.e., graduate students, postdocs, faculty) are also primarily men. This can be problematic, given that mentorship and role models are two key determinants of successful professional development [14]. A lack of mentorship means that students lack access to guidance on how to successfully navigate the path from their first year in college to a computing career. Further, a student who lacks role models may miss out on being inspired by others who are "like them", and have a physical reminder that success is attainable.

Action items

One way to boost women's sense of belonging in computing is to expose them to computing environments that are replete with other women. For example, the Computing Research Association's Committee on the Status of Women in Computing Research (CRA-Women) offers several programs (from undergraduate to senior professional levels) to increase the number of women who participate and succeed in computer science research. One aspect of CRA-Women programs is to build self-efficacy (a belief that one can successfully achieve an outcome) by providing role models, connecting participants to the research community, and building cohorts of participants at similar stages of the research pipeline. The CRA Center for Evaluating the Research Pipeline (CERP) has shown CRA-Women programs are effective at increasing the participation and success of the participants. For example, Grad Cohort is a two-day mentoring workshop, where successful senior women researchers serve as role models and give practical advice on navigating grad school (e.g., choosing an advisor and Ph.D. career paths); Grad Cohort senior women also provide personal insights on the challenges and rewards of their own careers. CERP

comparative evaluation shows that Grad Cohort participants tend to have stronger professional networks than non-participants. Since Grad Cohort receives significant funding from industry and NSF, the program is a cost-effective way for academic departments to bolster women's sense of belonging in the computing community.

Academic computing departments should also work hard to increase the number of women role models students see in their departments. A concrete way to do this is through the Distributed Lecture Series (DLS) program, which is co-sponsored by CRA-Women and the Coalition to Diversify Computing (CDC). The DLS program funds women and underrepresented minority researchers to visit universities and colleges to give a technical talk and participate in a variety of networking events including meetings with students to discuss professional development. The DLS program provides a nice opportunity for departments with few (if any) women/minority faculty to showcase successful underrepresented members of the computing community and create opportunities for professional interactions between these experts and students. Most of the cost of these visits is covered by the CRA-Women/CDC Alliance.

4. BIAS IN THE WORKPLACE

Once women make it through the academic pipeline and are at the professional level, they are confronted with a set of new challenges in addition to those they faced during their academic training. One such hindrance is bias in hiring and promotion. Although American culture emphasizes equal opportunity, recent research indicates that bias against women in STEM fields is a contemporary reality. For example, one study found that two promotion packages that were identical with the exception of the candidate's gender were evaluated differently. Specifically, evaluators of the woman's promotion package were four times as likely to write reservations or "cautionary comments" about the promotion decision than the man's promotion package evaluators were [15]. As a second example, Moss-Racusin and colleagues found that faculty members in science departments at universities across the U.S. evaluated two otherwise identical resumes for a research lab manager position differently, depending on whether the applicant was a woman or a man [16]. Specifically, faculty rated the male candidate more favorably, indicated more interest in mentoring him, and recommended offering a higher starting salary than the female applicant. Other research indicates that recommendation letters for women and men tend to be written differently; that is, letter writers focus more on competence-oriented traits (accomplishments such as skills and publications) when the letter concerns a man, but letter writers focus more on warmth-related traits (e.g., compassion and interpersonal skills) when the letter concerns a woman [17]. To the degree that letters of recommendation play a heavy hand in job candidates' competitiveness on the job market, this gender bias is debilitating for women's professional growth.

Other forms of bias against women is more systemic, such as inadequate support for maternity leave, poor childcare options, and little cultural value placed on work-family balance, all of which traditionally affect women more than men. Although these systemic cultural problems are pervasive across many fields, computing must focus on remedying these problems, given the fields' *particular* dearth of women.

Action items

When advertising for an open position, define your position as broadly as possible; research shows that positions broadly defined lead to a larger number of applicants and a more diverse pool. Also, search committees should try to remain blind to job applicants' identity (gender, race) for as deep into the application process as feasible. Blind review has been successful in fostering greater diversity among other fields, such as professional orchestras, which now conduct their first round of auditions behind a visually obstructing screen; this simple change to the audition process has significantly narrowed the gender gap in professional orchestras [18]. The same recommendation applies to the review processes for both peer-reviewed journals and funding agencies, all of which are still largely non-blind in computing.

Recommendations for systemic forms of bias against women in general include offering paid maternity leave; and offering options to omit periods of career evaluation (e.g., the tenure clock) during periods of childbirth, adoption, eldercare and other familial responsibilities. We also encourage leaders of both academic and industrial organizations in computing to conduct an "audit" of their staff salary, where they evaluate whether they offer similar salary levels to their male/female employees at similar levels. Unequal salary across women and men, despite equal qualifications across the genders, should signal to an organization that hiring and promotion procedures are biased in favor of men, and should be modified.

Lastly, CRA-Women offers two career mentoring workshops, one for junior women (i.e., shortly after earning a Ph.D.) and one for mid-career women (e.g., shortly after receiving tenure and promotion). In addition to providing participants with the sense of belonging (see Section 3), these workshops cover topics (e.g., finding advocates, negotiating skills, and promotion success), to help women succeed in computing even in the face of workplace bias. Since most of the cost of attending a CRA-Women career mentoring workshop is covered by an NSF ADVANCE grant, the program is a cost-effective way for academic departments to provide career mentoring for their female faculty. The cost is also minimal for women in industrial research lab positions, thanks to industrial support of the programs CRA-Women offer.

5. CONCLUSION

The cultural climate is oriented towards awareness of gender diversity, with special emphasis on the field of computing and technology. Accordingly, there is a plethora of social science research articulating the many reasons we do not see more women in computing. Thus, the time is ripe to apply those research findings to make social change a reality. Although the field of computing has the empirical resources and the cultural attention to guide and sustain our efforts, change requires unified motivation and cooperation among the entire community. It is not enough that a select few invest in this cause. This is not a "women's issue"; this is a "people's issue". Everyone can benefit from recalibrating the computing community to be universally inviting, inclusive and engaging.

6. REFERENCES

[1] S. Zweben and E. Bizot. Taulbee Survey. *Comp. Res. News* (May 2014).

[2] National Science Foundation. *Women, minorities, and persons with disabilities in science and engineering: 2007.* Retrieved from: http://www.nsf.gov/statistics/wmpd/2013/start.cfm?CFID=12490796&CFTOKEN=69188187&jsessionid=f030a5c574259f0058531514a2336276d374

[3] R. Lippa, Gender-related individual differences and the structure of vocational interests: The importance of the people–things dimension. *J. Pers. Soc. Psych*. 74 (1998) 996-1009.

[4] R. Su, J. Rounds, and P. I. Armstrong. Men and things, women and people: A meta-analysis of sex differences in interests. *Psych. Bull,* 135,(2009) 859-884

[5] A. B. Diekman, E. R. Brown, A. M. Johnston and E. K. Clark. Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psych. Sci.* 21 (2010) 1051-1057.

[6] J. G. Stout, N. Dasgupta, M. Hunsinger, and M. A. McManus. STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *J. Pers. Soc. Psych,* 100 (2011) 255-270.

[7]. S. Cheryan, V. Plaut, P. Davies and C. M. Steele. Ambient belonging: How stereotypical environments impact gender participation in computer science. *J. Pers. Soc. Psych.* 97 (2009) 1045-1060.

[8]. S. Cheryan, J. O. Siy, M. Vichayapai, B. J. Drury, and S. Kim. Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM? *J. Pers. Soc. Psych.* 2 (20011) 656-664.

[9] J. G. Stout, and N. Dasgupta. When he doesn't mean you: Gender-exclusive language as ostracism. *Pers. Soc. Psych. Bull.*, 37 (2011) 757-769.

[10] R. F. Baumeister and M. R. Leary. The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psych. Bull.* 117 (1995) 497-529.

[11]. L. H. Anderman & T. M. Freeman, in *Advances in motivation and achievement:* Vol. 13. Motivating students, improving schools: The legacy of Carol Midgley, ed. by M. Maehr & P. Pintrich, Elsevier, JAI, Oxford, 2004, pp. 27-63.

[12] K. Lewis, J. G. Stout, G. L. Cohen, S. J. Pollock, N. F. Finkelstein, and T. A. Ito. Fitting in to Move Forward: Using a Belonging Framework to Understand Gender Disparities in Persistence in the Physical Sciences, Technology, Engineering and Mathematics (pSTEM). (under review).

[13] M. Murphy, C. M., Steele, & J. Gross. Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psych. Sci.,* 18 (2007) 879-885.

[14] C. McKeen and M. Bujaki. In The Handbooks of mentoring at Work: Theory, research, and practice. ed. by B. R. Ragins and K. E. Kram, Sage Publications, 2007. P. 273.

[15] R.E. Steinpreis, K.A. Anders, and D. Ritzke. The Impact of Gender on the Review of the Curricula Vitae of Job Applicants and Tenure Candidates: A National Empirical Study, Sex Roles, 41(7/8), (1999) 509-528.

[16] C. A. Moss-Racusin, J. F. Dovidio, V. L. Brescoll, M .J. Graham, and J. Handelsman. Science faculty's subtle gender biases favor male students. *Proc. Nat. Acad. Sci.USA*, 109, (2012) 16474-16479.

[17] F. Trix, and C. Psenka, C. Exploring the color of glass: Letters of recommendation for female and male medical faculty. *Disc. Soc.,* 14 (2003) 191-220.

[18] C. Golden, and C. Rouse. Orchestrating impartiality: The impact of "blind" auditions on female musicians. *Am. Econ. Rev*., 90 (2000) 715-750.