Career Priorities and the Challenge of Recruiting Women to Computing

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“I always hear stories about how we can’t find enough engineers, we can’t find enough computer programmers... And that’s why we’re emphasizing math and science. That’s why we’re emphasizing teaching girls math and science.” – President Barack Obama, May 2011¹

Abstract

Misconceptions, lack of awareness, and lack of accurate information about computing occupations may lead women to reject or fail to even consider a career in computing. We document the compatibility between computing occupations and the shared and gendered career priorities of undergraduate college students. To assess students’ career priorities, we analyze data from the Persistence Research in Science and Engineering (PRiSE) project, which surveyed 7505 undergraduates across the United States. Then, we use occupational data from the United States Bureau of Labor Statistics to demonstrate that computing occupations offer many of the features that women identify as being important to their future career satisfaction. This type of information is needed to inform the teachers, counselors, and parents who advise young women, and to enable young women themselves to make informed choices about whether to pursue a career in computing. Finally, we discuss actions that educators and others can take to build women’s confidence in their ability to succeed in computing, and to counteract the stereotypes of computing that are most likely to deter women from considering a computing career.

Introduction

The gender disparity in computing is longstanding and has worsened over the last three decades. The percentage of bachelor’s degrees in computer science awarded to women peaked in 1984 at 37%, but has declined steadily since then. In 2012, women received 57% of all bachelor’s degrees, but only 18% of computer science bachelor’s degrees.² Similarly, in 2013 women held 57% of professional jobs overall, but only 26% of computer and mathematical jobs.³

The dearth of women in technology has become a pressing social and political issue. Underrepresentation leaves large numbers of women out of high quality, well-paying jobs, and contributes to suboptimal economic and personal outcomes. In addition, technical fields miss out on the benefits diversity brings to creative problem-solving and group decision-making.⁴⁻⁶ For example, companies with greater gender diversity in top management, as well as in the workforce, perform better on many measures of success, and teams containing more women perform better and display greater social sensitivity.⁷⁻⁹ The improved group processes found on teams with more women may be particularly beneficial in STEM fields, where teamwork and collaboration is crucial to innovation.¹⁰ For teams to benefit, however, gender parity, not simply the inclusion of small numbers of token women, is needed.^{10, 11}

In 2014, public dissatisfaction with the lack of diversity in technology led prominent companies such as Google, Facebook, Yahoo, Apple, Twitter, and others to release data on the diversity of their workforces, revealing pervasive underrepresentation of women (and minorities) in technology-related jobs, and leading to sweeping promises for change.^{12, 13} President Obama has singled out the lack of diversity in STEM fields as a serious problem, and his administration has launched a number of programs and initiatives aimed at least in part at increasing the representation of girls and women.¹⁴

Multiple factors likely contribute to the lack of women in technology and in other math-intensive STEM fields. Women may be influenced by mistaken cultural and self-perceptions of having lower mathematical or quantitative ability than men.¹⁵ Good, Rattan, and Dweck found that women who lack a sense of belonging in mathematics are less likely to pursue math-based disciplines, and that their sense of belonging is undermined both by stereotypes about women's lack of mathematical ability, and by beliefs that mathematics prowess is a fixed trait.¹⁶ Similarly, Leslie et al. found that women are the most underrepresented in both STEM and non-STEM fields where members tend to believe that fixed, innate talent is prerequisite for success in those fields. In these "brilliance required" fields, such beliefs may result in greater bias towards women, or lead women to opt out of the fields if they have internalized stereotypes that women lack the required aptitude.¹⁷

Socially shaped interests and lifestyle choices may also play a role in technology's gender imbalance. Women are still more likely than men to be concerned about their work-life balance and having time for family, and to choose jobs they perceive to be more compatible with those concerns.^{18, 19} Diekman et al. found that women more than men report valuing communal goals, such as working with or helping others, and believe that STEM careers do not fulfill these goals.²⁰ The current reality of these gendered interests was documented by Su, Rounds, and Armstrong's meta-analysis, which confirmed women's greater interest in people-oriented careers and men's interest in things-oriented careers, and found that men are consistently more interested in STEM areas than women.²¹

Negative stereotypes of computing and computer scientists have been widespread, and embody many characteristics likely to repel women. The "typical" computer scientist has been viewed as intelligent, nerdy, extremely focused on computers, socially inept, a loner, and male, and computing has been thought to involve heavy workloads and long hours of sitting at a computer.²²⁻²⁴ More recent images of "brogrammers" portray a frat-boy atmosphere unlikely to appeal to women.²⁵ These stereotypes may steer women away from careers where they feel like they won't fit in or be welcome. Furthermore, women's interest in computing may be undermined if they believe it is incompatible with other goals such as having a family, working with people, and helping people.

Misconceptions, lack of awareness, and lack of accurate information about computing occupations may lead women to reject or fail to even consider a career in computing. The

purpose of this paper is to document the career priorities of women soon to enter the workforce, and to compile occupational statistics that provide concrete evidence of the fit between computing occupations and the career priorities of these women. Our goal is to present existing occupational data in a form that is easy to understand, directly addresses women's career priorities, and allows direct comparisons between computing occupations and occupations that currently employ large numbers of women. This type of information is needed to inform the teachers, counselors, and parents who advise young women, and to enable young women themselves to make informed choices about whether to pursue a career in computing.

We analyze data on career preferences collected as part of the Persistence Research in Science and Engineering (PRiSE) project, which surveyed 7,505 undergraduate students across the United States about their backgrounds, high school science experiences, and science attitudes. Some results from the PRiSE project have been reported elsewhere (e.g.²⁶) but our analysis of career priorities from this large, mixed-gender sample is valuable to document shared and gendered career preferences for comparison with the reality of computing occupations. Next, we present occupational data from the United States Bureau of Labor Statistics to demonstrate that computing occupations offer many of the features that women identified as being important to their future career satisfaction. Finally, we discuss actions that educators and others can take to counteract the misconceptions about computing that are most likely to deter women from considering a computing career.

Methods

We compared male and female college students' career priorities with characteristics of computing occupations described by the U.S. Bureau of Labor Statistics.

Career Priorities

To assess students' career priorities, we analyzed data from the Persistence Research in Science and Engineering (PRiSE) project, which surveyed 7,505 undergraduate students from 40 colleges and universities across the United States in the fall of 2007. Colleges and universities were selected using a random sample stratified by institution type (2 year and 4 year) and size (small, medium, and large) to ensure that a diversity of institutions and students were represented. Students were enrolled in introductory English courses required of all majors, thus students interested and uninterested in STEM were included. Respondents were 49% female and 44% male, with 7% omitting their gender; 67% White, 14% Hispanic, and 8% Black, with smaller representations of other minority groups. Freshmen comprised 76.4% of the sample, sophomores 16.7%, and the remaining 6.9% were other levels. Students were asked about their backgrounds, high school science experiences, and science attitudes.

The current study analyzes student ratings of how important each of the following 15 job characteristics is to their future career satisfaction: *Making money*, *Becoming well known*, *Helping other people*, *Having others working under my supervision*, *Having job security*,

Working with people rather than objects, Inventing new things, Developing new knowledge and skills, Having lots of family time, Having lots of time for myself/friends, Making my own decisions, Having an easy job, Having an exciting job, Making use of my talents/abilities, Working in an area with lots of job opportunities. Characteristics were rated on a scale of 1 to 6, where 1 = *Not at all important* and 6 = *Very important*. (For more information on the PRiSE project and survey methodology, see ^{26, 27})

Occupational Data

The most recent available occupational statistics were obtained from the U. S. Bureau of Labor Statistics (BLS). These include 2013 figures for occupational minimum education requirements, wages, average hours worked per week for workers over age 16 who usually work full time, and the percent of female workers for particular occupations. The median years of tenure with current employer was reported in January 2014. Every two years, the BLS projects percent growth for occupations, and the number of jobs expected to become available due to growth and replacement over the next ten years; most recent estimates are for 2012-2022. Similarly, the distribution of computing jobs across industries is projected for 2022.

Selection of Occupations for Comparisons

The 2010 Standard Occupational Classification (SOC) system used by the BLS utilizes 4 levels of occupations: major group, minor group, broad occupation, and detailed occupation. Our comparisons generally focus on the broadest level, major occupational groups, and the narrowest, detailed occupations.

Computer occupations are included in the major occupational group Computer and Mathematical Occupations (code 15-0000). However, computer occupations account for 96.5% of this category (in 2012, the employment figure was 3,682,300 for computer occupations, vs. 132,400 for mathematical occupations),²⁸ thus figures given for Computer and Mathematical Occupations primarily represent the characteristics of computer occupations.

We also present statistics for the 12 detailed occupations categorized as Computer Occupations by the BLS (SOC numerical code beginning with 15-11), as well as two additional occupations, Computer and Information Systems Managers (code 11-3021, categorized as a Management Occupation) and Computer Science Teachers, Postsecondary (code 25-1021, categorized as an Education, Training, and Library Occupation) because both typically require a computer science or related degree. All of these occupations require post-secondary education, with three requiring a minimum of some college or an associate's degree, nine requiring a minimum of a bachelor's degree, and two requiring a doctorate or professional degree.²⁹

To illustrate how computing occupations compare to occupations that girls and women are particularly likely to consider, we identified all non-computing occupations that 1) require post-secondary education,²⁹ 2) in 2013 employed females as more than 50% of their workforce,³ and 3) are expected to have many job openings, defined as more than 100,000 jobs projected to become available due to growth and replacement for 2012-22.²⁹ Because this method resulted in

very few comparison occupations requiring a doctorate or professional degree, we included two additional occupations, Lawyers and Physicians. Both met the criteria for projected job openings, although each employs fewer than 50% women (33.1% and 35.5%, respectively). Thus, 17 non-computer occupations are compared with 14 computer occupations. (Although computing as a whole is growing, and several computer occupations are projected to have more than 100,000 jobs becoming available, we present data for all computing occupations regardless of projected growth.)

Where specific occupations are compared, data at the level of detailed occupation were used, whenever possible. However, for average hours worked per week,³⁰ and for the percentage of workers who are female,³ data for some occupations were not given at the detailed occupation level; in these cases, we used the figure given for the next level up. For example, for hours worked, separate figures were not available for the detailed occupations *Computer Network Support Specialists* and *Computer User Support Specialists*. For both, we therefore used the figure given for the broad occupation, *Computer Support Specialists*.

Results

We found strong similarities in male and female priorities for career satisfaction, and alignment of these priorities with the conditions in computing careers.

What do Young People Want in a Job?

Women's and men's mean ratings of the 15 job characteristics associated with their future career satisfaction were highly correlated ($r(13) = .96, p < .001$). Furthermore, there was a clear division in the mean ratings of the job characteristics. For four characteristics, females' and males' mean ratings were below the scale's midpoint of 3.5, indicating that these characteristics are relatively unimportant to career satisfaction; these were *Having others working under my supervision*, *Having an easy job*, *Becoming well known*, and *Inventing new things*. For further analyses, we focused on the remaining 11 characteristics, all of which women and men rated at or above 4 on the 6 point scale. (Figure 1)

Figure 1. Women's and men's mean ratings of the importance of job characteristics to career satisfaction (1=Not at all important, 6=Very important) $r=.96$

The remaining 11 job characteristics were *Making money*, *Helping other people*, *Having job security*, *Working with people rather than objects*, *Developing new knowledge and skills*, *Having lots of family time*, *Having lots of time for myself/friends*, *Making my own decisions*, *Having an exciting job*, *Making use of my talents/abilities*, and *Working in an area with lots of job opportunities*. Independent samples t tests were conducted to explore gender differences in the ratings of these job characteristics. However, with a sample size of over 7,500, statistical power is high, and even very small differences are likely to reach statistical significance. For all comparisons that were significant at $p<.05$, we calculated Cohen's d , a measure of effect size, to evaluate whether differences were large enough to be considered meaningful. Cohen's $d=.2$ is generally interpreted to represent a small effect size, $d=.5$ a medium effect size, and $d=.8$ a large effect size.

Women's and men's ratings did not differ significantly for *Making my own decisions*, *Developing new knowledge and skills*, and *Having lots of time for myself/friends*. Statistically significant differences were obtained for the remaining characteristics. However, the effect sizes were negligible (all d 's $<.15$) for *Making use of my talents/abilities*, *Having job security*, *Having an exciting job*, *Working in an area with lots of job opportunities*, and *Making money*. Small effect sizes were found for *Having lots of family time* ($d=.23$) and *Working with people rather than objects* ($d=.40$), and a medium effect size was obtained for *Helping other people* ($d=.52$), all of which women rated as being more important to their career satisfaction than did men (Table 1).

Table 1. Comparison of women's and men's ratings of the importance of job characteristics to career satisfaction (1 = not at all important, 6 = very important).

Job Characteristic	Women Mean (SD)	Men Mean (SD)	t (df)	p	Cohen's d
Helping other people	5.18 (1.11)	4.55 (1.30)	21.29 (6666)	.000	0.52
Working with people rather than objects	4.58 (1.40)	4.01 (1.46)	16.06 (6631)	.000	0.40
Having lots of family time	5.06 (1.08)	4.80 (1.18)	9.50 (6739)	.000	0.23
Making use of my talents/abilities	5.27 (0.91)	5.19 (0.96)	3.44 (6767)	.011	0.09
Having job security	5.13 (1.14)	5.05 (1.14)	2.56 (6661)	.011	0.07
Having an exciting job	5.03 (1.07)	4.97 (1.12)	2.41 (6748)	.016	0.06
Working in an area with lots of job opportunities	4.91 (1.14)	4.75 (1.20)	5.79 (6760)	.000	0.14
Making money	4.76 (1.21)	4.84 (1.21)	2.57 (6868)	.010	0.07
Making my own decisions	4.90 (1.07)	4.88 (1.07)	.88 (6694)	.382 n.s.	
Developing new knowledge and skills	4.62 (1.34)	4.60 (1.27)	.49 (6746)	.623 n.s.	
Having lots of time for myself/friends	4.53 (1.20)	4.49 (1.17)	1.27 (6759)	.206 n.s.	

In summary, our analysis shows that women's and men's ratings of the importance of job characteristics to career satisfaction were overall quite similar. For both genders, there was a clear split between those characteristics that were not considered important, and those that were considered important. Among those characteristics both genders considered important, most either did not show gender differences at all, or displayed gender differences of negligible magnitude. Exceptions were the following characteristics which women rated as being more important: *Having lots of family time*, and *Working with people rather than objects*, for both of which the effect size was small, and *Helping other people*, for which the effect size was moderate. However, it is important to note that in spite of the gender differences, these job characteristics were rated as being quite important by men as well as by women.

Occupational Statistics

We used data published by the U.S. Bureau of Labor Statistics to compare computing to other occupations, and to show that computing occupations offer many of the characteristics young people believe are important to their future career satisfaction. In particular, occupational statistics demonstrate computing's compatibility with the highly rated job characteristics *Having job security*, *Working in an area with lots of job opportunities*, and *Making money*, as well as with those job characteristics having to do with work/life balance such as *Having lots of time for myself/friends*, and *Having lots of family time*, the last characteristic being particularly important to women. *Working with people rather than objects* and *Helping other people* are not covered by

the occupational statistics, but were also particularly important to women, and will be addressed in the discussion section.

Growth of computing. The availability of job opportunities was important to both men and women. Computing and Mathematical Occupations is one of the fastest growing major occupational groups, with 18% growth projected between 2012 and 2022 (Figure 2), and approximately 1.24 million computing jobs expected to become available due to growth and replacement over this period.²⁸

Figure 2. Percentage job growth due to growth and replacement for major occupational groups, 2012-2022.²⁸

Job tenure. Job security was important to both men and women. Data from the Bureau of Labor Statistics indicate that in January, 2014, employees in Computing and Mathematical occupations had been with their current employer for a median of 5.0 years, which is longer than the overall median of 4.6 years for all occupations combined, although somewhat shorter than the median of 5.3 years for professional occupations.³¹

Pay. Both male and female undergraduates rated making money as important to their future career satisfaction. Compared with other occupational groups, computing pays very well. The median annual pay for Computer and Mathematical occupations in 2013 was \$77,860, second only to Management Occupations.³² (Figure 3)

Figure 3. 2013 median annual wages (rounded to the nearest thousand) for major occupational groups.³²

Figure 4 compares wages for specific computing occupations to occupations that are attractive to women and require comparable education.³² The minimum education required for the majority of computing jobs is a bachelor's degree. Within this educational category, all computing jobs pay better than all but two of the other occupations that have large numbers of projected job openings and employ workforces that are more than 50% women. Particularly with an intermediate level of education, computing jobs are lucrative.

Figure 4. 2013 median annual wages³² (rounded to the nearest thousand) for computing occupations, and for occupations that employ workforces that are >50% women and require comparable levels of education. Within each education level, occupations are ordered by median wage.

Hours worked. To address the quality of life issues of having time for family, friends, and other activities, we compare the average work week for Computing and Mathematical occupations to other major occupational groups.³⁰ (Figure 5) The Computer and Mathematical occupations average of 42.1 hours per week is slightly below the mean of 42.5 hours for all.

Figure 5. 2013 average hours worked per week by major occupational group³⁰

Figure 6 shows that the average hours worked in computing occupations are similar to those worked in other occupations women often pursue, and are notably less than hours worked in occupations such as Doctors and Lawyers.

Figure 6. 2013 average hours worked per week³⁰ for computing occupations, and for occupations that employ workforces of >50% women and require comparable levels of education. Order of occupations is as in Figure 4.

Distribution of jobs across industries. Although the largest percentage (39%) of computing jobs are found in Professional, Scientific, and Technical Services, the remaining 60% of computing jobs are in other areas, including Health and Social Assistance, Finance and Insurance, Information, Education, Government, Data Processing, and Manufacturing.³³ (Figure 7) According to the BLS, computing occupations are more widely distributed across industries than any other type of occupation. For workers, more types of employers translates into opportunities to seek out those jobs that offer the schedules, wages, benefits, and geographic locations that best meet the workers' needs.^{34,35}

Figure 7. 2022 projected distribution of computing jobs across industries³³

Discussion

Overall, the male and female college students surveyed had similar career priorities. Both genders placed importance on job security, working in a field with a lot of job opportunities, and making money. Both genders were concerned about having time for themselves and friends, having a job that is exciting, and that allows them to make their own decisions and develop new skills and knowledge. Gender differences on these items either were not statistically significant, or were of negligible magnitude. Women attached more importance than men to having time for family and working with people rather than objects, and in particular, to having a job that involves helping others, although these items were important to men as well. The overall similarities between men's and women's career priorities, but with women placing greater

emphasis on family considerations, working with people, and helping people, is highly consistent with previous research.¹⁸⁻²¹

Occupational statistics compiled by the U. S. Bureau of Labor Statistics demonstrate that computing ranks very highly on many measures of job quality, and fulfills many of the job characteristics that both women and men identify as being important. Computing is expected to continue to grow rapidly, with about 1.24 million jobs becoming available over the next decade; thus job opportunities should be abundant. Comparisons of job tenure suggest that computing offers security similar to other professional jobs, and more security than jobs in many other fields. Furthermore, the availability of many jobs should make replacing a lost job less of a concern. Computing occupations pay very well, both when compared with other major occupational groups, and when compared with other occupations having similar, and in particular intermediate, educational requirements. The pay advantage is especially evident when computing occupations are compared with occupations where women often work.

Both men and women were concerned about having time for themselves, friends, and family, with women in particular placing importance on time for family. Occupational data on mean hours worked per week indicate that the stereotype that computing involves heavy workloads and long hours is inaccurate. Both compared with other major occupational groups, and with specific occupations with similar educational requirements that employ high percentages of women, the average hours worked per week for computing occupations are typically moderate, and are far less than for occupations like doctor and lawyer. Furthermore, computing jobs are widely distributed across industries, giving workers flexibility to seek out those jobs that offer the schedules, wages, benefits, and geographic locations that best meet their needs.³⁴

Recommendations

Based on our findings, we recommend that the occupational statistics presented in this paper be used to inform young women and those who influence them about the benefits of pursuing a career in computing. Such information could be used by high school guidance counselors and teachers, by college faculty advisors and career center personnel, or could be made available to students in high school or college computing classes. (To order or download an easy-to-use resource for this purpose, see www.ncwit.org/resources/computing-get-most-out-your-college-degree.) But to gauge whether computing occupations are a good fit for their interests and ambitions, students also need to be exposed to the nature and diversity of computing occupations. In the following, we discuss other research-supported recommendations for involving girls and women, and more diverse students in general, in computing.

Computing is often inaccurately stereotyped as a “geeky” or masculine endeavor. Classroom practices, both at the K-12 and college level, can do much to counteract these stereotypes and encourage interest and feelings of belongings in women. For example, physical environments that are gender neutral (e.g. contain plants, artwork, or nature pictures) and avoid computing stereotypes, such as science fiction or gaming posters, have been shown to appeal to women without affecting men’s interest.³⁶ Thus, computer science teachers, college faculty, and

computer science departments should consider creating classrooms, labs, and common spaces that are warm and inviting and feature neutral, non-stereotyped décor.

Although it is seldom emphasized to students, computing occupations require collaboration and teamwork, and have great potential for helping people, both of which are particularly important to women. In the classroom, collaborative learning practices, such as pair programming and peer-led team learning, emphasize the social aspects of computing and facilitate peer support among students.^{37, 38} Use of curricula that include examples and assignments aligned with students' interests, that present computing in the context of solving important real world problems, and that show computing's applications across many fields, also help broaden the discipline's appeal.³⁹⁻⁴¹ Advisors and instructors should emphasize computer science's connections to fields such as biology, medicine, business, education, and social sciences, and inform students about college programs that facilitate combining computer science with other interests, including majors such as Informatics, alternative degree paths such as bachelor of arts degrees in computer science, and tracks within computer science majors that focus on specific areas of interest.

Piquing women's interest will not be enough if they are not confident they can succeed. Women often enter computing classes with little previous programming experience, so offering classes designed for students new to computing increases retention and builds student confidence.³⁹ Furthermore, when instructors develop personal relationships with, mentor, and encourage women, those students' confidence increases.⁴² Additionally, encouraging students to adopt a "growth mindset," where students understand that success results from effort and hard work, rather than innate ability, has been shown to improve confidence, performance, and the ability to persist in the face of challenge.⁴³

Conclusion

Women considering a career in computing need accurate information about the field. The occupational statistics presented in this paper can show young women and their advisors that computing provides high quality jobs and many of the career characteristics women desire. Furthermore, educators at all levels can counteract misconceptions about computing by intentionally exposing students to the diverse, collaborative, and prosocial nature of computing, while promoting development of the skills and confidence needed to succeed.

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