Examining the Underrepresentation of Women in STEM Fields

EARLY FINDINGS FROM THE FIELD OF COMPUTER SCIENCE

by Linda J. Sax

ENIAC, first general-purpose electronic computer, photo from the archive of historic computer images on the U.S. Army website, http://ftp.arl.army.mil/ftp/historic-computers/

DESPITE an emphasis in recent decades on creating equitable classrooms and recruiting young women into science, technology, engineering and mathematics (STEM), women have been persistently underrepresented in the STEM disciplines in both higher education and the workforce (Davies & Guppy, 1997; England & Li, 2006; Fox, 2001; Jacobs, 1995; 1996; Mullen, 2010; Sax, 2008; Spelke, 2005; Turner & Bowen, 1999). Except for the biological sciences, which now attract slightly more women than men, women remain underrepresented across the STEM fields, and most particularly in physical science, engineering, and computer science (see Figure 1) (Sax, Jacobs & Riggers, 2010).

Over time, research has identified key issues affecting women's interest and enrollment in STEM fields (Margolis & Fisher, 2002; Sax, 2001; Seymour & Hewitt, 1994; Sonnert, 1995; Xie & Shauman, 2003). These factors generally fall into five categories: demographics (for example, race and class), academic background (for example, the number and level of mathematics and science classes taken in high school), self-confidence (such as perceptions of one's ability in math and science), personality and values (including level of interest in scientific careers, work-related values and preferences), and structural barriers (for example, classroom experiences and support of others outside the classroom setting) (Blickenstaff, 2005; Cole & Espinoza, 2008; Espinosa, 2009; Kinzie, 2007; Sax, 1994; 2001; 2008).

Despite the plethora of studies examining the root causes of the gender gap in STEM, a significant problem is that most research considers STEM fields in the aggregate and does not account for possible differences in the factors that predict interest and enrollment in *specific* STEM fields. Because not all STEM fields face the same degree of gender segregation, we cannot expect all STEM fields to attract the same types of students, especially since students likely have different motivations for pursuing one STEM field versus another.

Further, while predictors of STEM aspirations have been identified in numerous studies, research has generally not examined the extent to which explanations for women's underrepresentation in STEM may have *shifted* over the years. Since the characteristics of college-going women and men have changed over time (Sax, 2008), and perceptions of various STEM fields may have evolved over the years, it is important to know whether individual STEM disciplines attract a

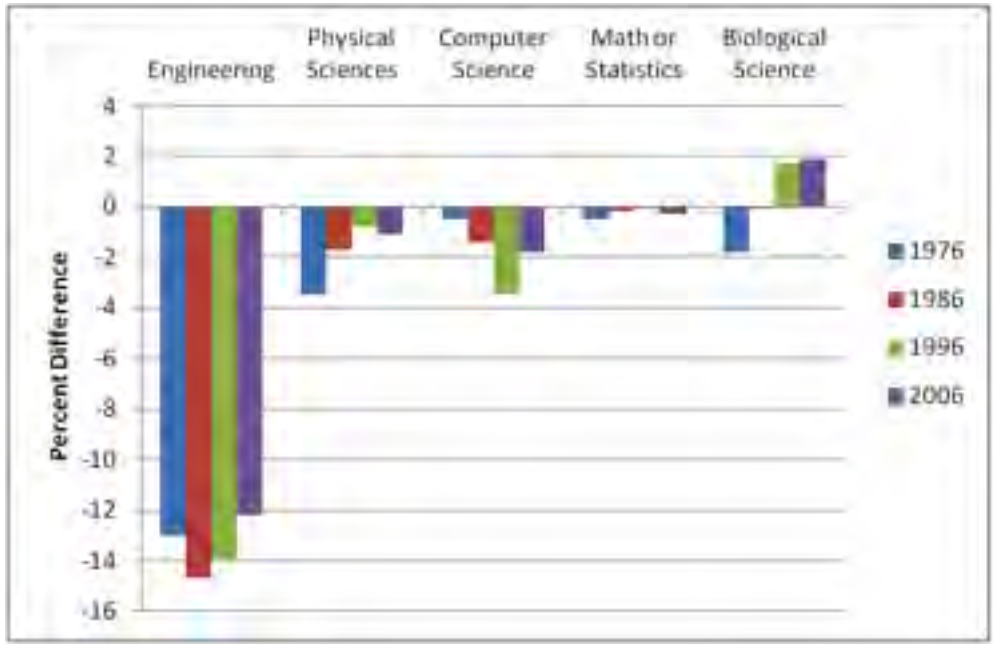

Figure 1. Difference in the percentages of women and men intending to major in STEM by field and year. *Source: Cooperative Institutional Research Program, UCLA*

different configuration of women and men today than in the past.

To explore these questions, my research team and I (along with my co-principal investigator, sociologist Jerry Jacobs from the University of Pennsylvania) are currently engaged in a study of the changing determinants of the gender gap in five STEM fields: engineering, computer science, biological science, physical science, and math/statistics. This research is supported by a grant from the National Science Foundation (HRD #1135727) with additional support provided by a Faculty Development Grant from UCLA's Center for the Study of Women.

Our research benefits from a massive dataset of more than 10 million college students surveyed via the "Freshman Survey" administered at over 1,000 colleges and universities over the past four decades. The Freshman Survey is a national longitudinal study of entering college students conducted by the Cooperative Institutional Research Program (CIRP) at UCLA's Higher Education Research Institute. The Freshman Survey includes dozens of measures relevant to STEM, including: self-ratings of academic and mathematical abilities, high school academic achievement and preparation, major choice, academic and career goals, life goals, value orientations, and demographic backgrounds. Our study will access data between 1971 and 2010 with the ultimate goal of advancing our understanding of the types of women and men who pursue specific STEM majors, and how those characteristics vary both across STEM fields and over time.

GUIDING QUESTIONS

Our research utilizes national data on incoming college students collected over the past 40 years to address the following research questions:

- How has the gender gap in incoming students' intent to major in STEM fields changed over the past three decades?
- Over the past three decades, to what extent are the changes in the gender gap in STEM majors due to: (1) shifts in the *distribution* of characteristics (for example personality, self-confidence, and educational orientations) among undergraduate women and men, or (b) shifts in the *predictive power* of variables for women and men?
- How has the salience of the specific student characteristics predicting selection of STEM majors changed over time for women and men?

A FOCUS ON COMPUTER SCIENCE

We are in the early stages of this three-year project, and have elected to begin our investigation by focusing on the field of computer science. Given the importance of computer science as a foundation for technological advances, the field offers an interesting case for understanding the underrepresentation of women in STEM in general. Indeed, computer science exhibits one of the most severe gender imbalances among the STEM fields, with female college students comprising less than 18 percent of all bachelor's degree recipients in this field in 2008-09 (U.S. Department of Education, 2011).

Interestingly, though computing occupations represent an increasingly dominant share of STEM occupations (Carnevale, Smith & Melton, 2011), the study of computer science does not enjoy the same popularity as it had during the rise of the personal computer in the early 1980s and the Internet boom of the late 1990s. In fact, bachelor's U.S. degree production in computer science has been on a sharp downward slope since 2004 (U.S. Department of Education, 2011). Some computer scientists view the decreased popularity of the field as a sign of crisis, suggesting that the computer science field is losing potential talents to other prominent fields such as finance or bioinformatics (Foster, 2005). Understanding the predictors of computer science interest for all students, with special attention to women as a population that is underrepresented in the field, will aid efforts to increase the enrollment and diversity of the computer science field.

Moreover, with regard to the gender gap, the underrepresentation of women in computer sci-

ence has important consequences for individual women and for society as a whole. First, argued at the individual level, women's lack of interest and participation in computer science education and hence the workforce translates into a gender gap in economic opportunities, as computing occupations often offer relatively high salaries (Margolis & Fisher, 2002). Secondly, considered at a broader level of national competitiveness and the field of computer science itself, the absence of contributions from women (a group that makes up a significant portion of our population, and more than half of our new college graduates) undermines the competitiveness of the computing labor force by limiting the range of perspectives and considerations of its participants (Carnevale et al., 2011; Lewis, Harris, & Cox, 2000; Margolis & Fisher, 2002; Papadopoulos, 2006). The lack of women in computer science also works against efforts to recruit greater diversity into the field by perpetuating a more homogenous (masculine) image of the field (Lewis, Harris, & Cox, 2000), thereby creating a cycle of discouraged participation by women.

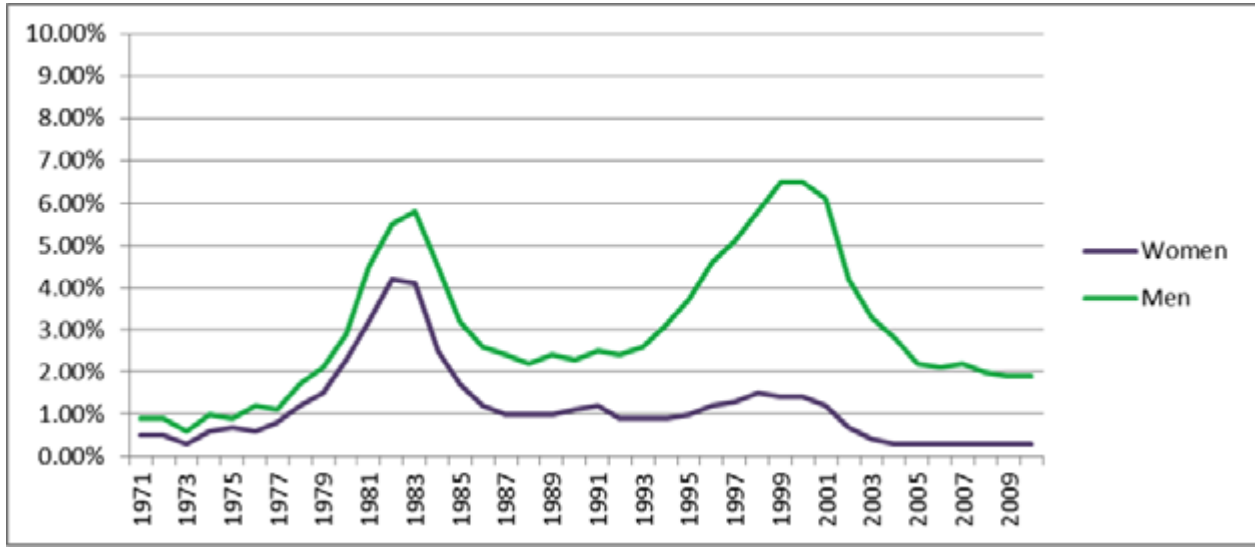

Figure 2. Proportion of first-year women and men intending to major in computer science. *Source: Cooperative Institutional Research Program, UCLA*

EARLY RESULTS

Though it would be easy to describe women in computer science simply as "underrepresented," in actuality *women's underrepresentation in computer science has fluctuated over time* (see Figure 2). Two particularly notable periods are the advent of personal computers in the late 1970s and the Internet boom in the late 1990s. Though the first period was successful in attracting women, the second period was not. Notably, both periods reveal a widening of the gender gap pertaining to interest in computer science among entering college students. Interestingly, the gender gap in computer science interest is actually larger today than it was decades ago, revealing a trend that is not observed among other STEM fields where the gender gap has remained fairly stable (for example, engineering, math/statistics) or has diminished (for example, biological science).

These trends beg the question of why computer science remains so unattractive to women, even during times when the field of computing has offered (or appears to have offered) many opportunities. One interpretation for the starkly different trends for women and men is that the two genders differ on traits that are important in selecting a computer science major or career, such as an interest in science and high confidence in one's mathematical abilities. Another interpretation may be that there are gender differences in the *reasons* why women and men pursue computer science; thus, fluctuations in computer science interest might reflect students' changing perception of the field.

Accordingly, our second research question examines these possibilities by calculating the

proportion of the computer science gender gap that is explained by mean-level differences in the characteristics of women and men, versus gender differences in the predictors of computer science interest. Preliminary analyses reveal that, especially in recent decades, *the primary explanation for the gender gap is that women and men differ in the factors that predict interest in computer science*. This finding suggests that efforts to close the gender gap in computer science would be unsuccessful if the goal were simply to align women's and men's average levels on characteristics such as math confidence (a positive predictor) or interest in social activism (a negative predictor). Instead, efforts to recruit more women into computer science ought to be sensitive to the fact that women and men differ slightly in their *reasons* for selecting (or not selecting) computer science as a field of study.

To explore this further, our third research question sheds light on which specific predictors of computer science interest differ for women and men and how this has changed over time. Early results reveal *gender differences in the salience of the vast majority of student characteristics examined*. That is, either the predictive power is significantly different for women and men or a characteristic predicts computer science interest for one gender only. For example, math self-confidence has become a weaker predictor of computer science interest for both women and men. As the nature of the field has evolved, especially with the rapid growth of computer technologies and applications, are students less likely to view mathematical skills as a necessary prerequisite for computer science? If yes, such a trend would bode well for reducing the gender gap in computer science, since women's consistently lower ratings of math ability often preclude them from pursuing STEM fields (Sax, 2001, 2008). In addition, we have found that artistic inclinations have become less of a deterrent to majoring in computer science for women, but not for men. This raises the question of whether women increasingly view computer science as a way to express or apply their artistic abilities. Combined with the declining salience of math ability self-ratings, these early results provide some evidence that the perception of computer science may have shifted slightly away from a math-focused field, and perhaps more towards a creative vocation, at least for women. As we continue in our research, we will explore this possibility in greater depth.

CONCLUSION

As this research project further examines computer science, and then moves on to the engineering, math/statistics, physical sciences and engineering fields, it will generate new knowledge about *which* types of incoming male and female college students are attracted to *which* STEM fields, and how these characteristics have *changed over time*. Such information is critical because it can inform and improve efforts to recruit a diverse population of women (and men) into the scientific and technological workforce. Awareness of gender differences in these shifting characteristics can help to specifically recruit women to STEM fields where they are most underrepresented (for example, engineering and computer science). Without this knowledge, STEM recruitment efforts at all levels of education run the risk of relying on long-standing assumptions regarding which women and men are likely to enter these fields at the aggregate level. By expanding our understanding of who chooses STEM fields, and how that has changed over time, this project will provide a service to society at large, encouraging educators and administrators to consider how teaching, recruitment, and outreach practices might be altered to reduce the gender gap in college STEM participation.

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