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Growing the roots of STEM majors: Female math and science high school faculty and the participation of students in STEM

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ABSTRACT

The underrepresentation of women in science, technology, engineering, and mathematics (STEM) fields is problematic given the economic and social inequities it fosters and the rising global importance of STEM occupations. This paper examines the role of the demographic composition of high school faculty—specifically the proportion of female high school math and science teachers—on college students' decisions to declare and/or major in STEM fields. We analyze longitudinal data from students who spent their academic careers in North Carolina public secondary schools and attended North Carolina public universities. Our results suggest that although the proportion of female math and science teachers at a school has no impact on male students, it has a powerful effect on female students' likelihood of declaring and graduating with a STEM degree, and effects are largest for female students with the highest math skills. The estimates are robust to the inclusion of controls for students' initial ability.

1. Introduction

The need to expand the science, technology, engineering and mathematics (STEM) workforce has become increasingly pressing in the last 20 years. Although the number of students earning STEM degrees has grown substantially in the last decade, the supply for the STEM workforce continues to trail the nation's demand. For example, the Bureau of Labor Statistics reported that the U.S. economy is expected to add at least 1.2 million computer science jobs from 2010 to 2020, but at the current pace, U.S. universities will only produce half the number of computer science graduates needed to fill those positions (Atkinson, 2013). Currently the mismatch between the STEM workforce supply and the economy's demand is filled by immigrant workers, but this is a short-term solution that soon will be neither politically sustainable nor economically efficient (Ehrenberg, 2010). As a consequence, policy makers have openly acknowledged that the United States needs a long-term strategy to ameliorate the shortage of STEM graduates.

One untapped potential for increasing the numbers of STEM graduates is the population of female college students. Women are the majority of college students but represent a distinct minority of STEM degree holders. Although some STEM fields have started to graduate greater numbers of women (e.g., biology), strikingly few young women graduate with degrees in the physical sciences and engineering. This pattern draws attention to a major factor in the STEM workforce supply–demand dilemma: only a small number of women pursue STEM careers. National Science Foundation (2009) statistics report colleges and universities awarded only 40% of their STEM bachelor degrees to women (and most of these in the biological sciences). The attrition of women from STEM fields continues as they move into the

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labor market, where only 27% of STEM related jobs are held by women despite the fact that more than half of U.S. workers are female. Clearly, one strategy to fill the shortage in the supply of STEM workers is to encourage women to pursue STEM careers. Because these careers require specialized higher education, the factors related to the relatively weaker participation of women in college STEM majors are important topics of study.

The unequal participation by gender in STEM can potentially be explained by a variety of factors including: differential societal expectations for boys and girls, where boys receive more encouragement to pursue STEM fields (Ceci & Williams, 2007); a paucity of women role models and/or mentors (including school teachers and college professors) in STEM fields (Sonnert & Fox, 2012); and/or discriminatory environments and chilly climates (Hall & Sandler, 1982). Additionally, young women are likely to indicate that female teachers play important roles in shaping their early interests in STEM (Jackson, n.d.). We examine the role of the demographic composition of high school faculty—specifically the proportion of female high school math and science teachers—on college students' decisions to declare and/or graduate in STEM fields. Our results suggest that although the proportion of female math and science teachers at a school has no impact on male students, it has a powerful effect on female students' likelihood of declaring and graduating with a STEM degree, and effects are largest for female students with the highest math skills.

2. Previous research

Prior research has revealed a number of factors that affect women's decisions to participate in college STEM programs. This body of research suggests the importance of female college faculty for the STEM outcomes of women during the college years (Canes & Rosen, 1995; Hoffmann & Oreopoulos, 2009; Kokkelenberg & Sinha, 2010; Newmark & Gardecki, 1998; Price, 2010; Rask, 2010; Rothstein, 1995; Robst, Keil, & Russo, 1998). Most of these studies analyze the relationship between the persistence of students in STEM fields and the gender match between college faculty and students (Bettinger & Long, 2005; Griffith, 2010; Price, 2010; Robst, Keil, & Russo, 1998). However, several studies also look at the link between women's choices of STEM major and the proportion of female faculty at the college, sometimes referred to as the demography of the department (Canes & Rosen, 1995; Carrell, Page, & West, 2010; Qian, Zafar, & Xie, 2009; Rothstein, 1995).

2.1. Persistence and course taking behavior

Studies have indicated some mixed effects related to the presence of female university faculty on female college STEM outcomes. A portion of these studies analyze the relationship between the persistence of students in STEM and the gender ratio between faculty and students. For example, Robst, Keil, and Russo (1998) show that the percentage of female math and science teachers in college has a strong positive link to women's retention in science, mathematics and engineering. At the same time, one study concluded that female students are no more likely to persist in a STEM field when they enroll in courses taught by female faculty (Price, 2010) and another found that female students' persistence in STEM fields was unaffected by the gender makeup of the STEM faculty (Griffith, 2010). Regarding course taking behavior, research has found that the likelihood of female students taking courses and majoring in mathematics, statistics, geology, sociology, and journalism was significantly higher when they were taught by female faculty (Bettinger & Long, 2005). Recently, Griffith (2014) reported that although major choice and course-taking behavior are mostly unaffected by the gender match between faculty and student, students earn higher grades in courses taught by same-gender instructors in fields like STEM fields that have traditionally been dominated by the opposite gender.

2.2. Graduating with a STEM degree

Studies have demonstrated that as the percentage of female faculty in STEM departments increases, the percentage of four-year degrees awarded to females in these departments will also increase (Qian, Zafar, & Xie, 2009). Prior research has also found a positive association between the percentage of female faculty and the probability that a female student will earn an advanced degree (Rothstein, 1995). Furthermore, Carrell, Page, and West (2010), using a sample of college students randomly assigned to professors, found that female professors have a powerful effect on high-performing female students' likelihood of graduating with a STEM degree. However, when Canes and Rosen (1995) analyzed the effect of the proportion of women in a department's faculty on the number of female majors within that department, they found no evidence that an increase in the share of women on a department's faculty led to an increase in its share of female majors. The mixed results regarding the influence of the gender distribution of college faculty on students' STEM outcomes suggest that looking at high school experiences might be able to shed more light on STEM college major choice.

2.3. Pre-college years

There is less research focused on the importance of female teachers during the pre-college years on young women's STEM outcomes. This is surprising given the fact that emerging evidence suggests that the pre-college setting is highly influential on students' choice of major in college (Maltese & Tai, 2011). The majority of studies that focus on pre-college years examine the gender match between teacher and student and its effect on students' non-STEM outcomes, such as achievement and engagement (Dee, 2005, 2007; Nixon & Robinson, 1999; Winters, Haight, Swaim, & Pickering, 2013). What is missing from the corpus of research is an analysis of how the proportion of female STEM high school teachers, as a whole, affects students' STEM participation in college.

By looking at the proportion of female math and science teachers at the high school students attended, we seek to gain insight into how the gender composition of the high school faculty influences student outcomes. Importantly, this paper shifts the attention of the inquiry about the role of women faculty from individual teachers to the proportion of women