Abstract Title Page

Title: Are Two-Year Colleges the Key to Expanding the Scientific Labor Force? Unpacking Gender and Racial-Ethnic Gaps in Undergraduate STEM Degrees

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Abstract Body

Purpose / Objective / Research Question / Focus of Study:

Problematically, most studies have excluded two-year college students from their analyses of the gender gap in scientific majors, specifically in science, technology, engineering, and mathematics (STEM) fields. Existing research on the STEM gender gap in college tends to focus on students attending four-year, residential and often elite institutions (e.g., Cech, Rubineau, Silbey, & Seron, 2011; Mullen, 2013). While it may have been acceptable in the past to exclude the production of scientific degrees at two-year colleges from scholarly inquiry, major changes in the college population, compounded by multiple economic recessions, have made overlooking two-year degrees a serious oversight. Standards for mathematics and science course taking have increased across a broad array of high schools (Dalton, Ingels, Downing, & Bozick, 2007; Gutièrrez, 2000; Schiller & Muller, 2003), positioning a wider and more diverse set of U.S. youth to pursue postsecondary degrees in the sciences. Moreover, a recent Brookings study found that 50% of STEM jobs require an Associates' degree or less (Rothwell, 2013). During the recent U.S. recession, two-year colleges saw increased enrollments, enrolling 44.5% of traditional-age college students in 2009 (Dunbar, et al., 2011). These trends suggest the growing importance of two-year colleges in accommodating both the increasingly diverse supply of STEM-trained high school graduates and the growing demand for workers to fill STEM positions.

Given the explosion of theoretical and empirical interest in the STEM gender gap in recent years, almost exclusively focused on four-year colleges, this paper primarily investigates the following question: how does the nature of the gender gap differ among two- and four-year college students, if at all? This study seeks to answer the following sub-questions: first, to what extent do men and women differ in the scientific degrees they complete? Second, how does the gender gap in scientific degrees vary by race-ethnicity? Next, how do individual background, pre-college, and college characteristics explain the gender gap in scientific degrees, and in particular in natural/engineering sciences degrees? Finally, with the growing number of students attending two-year colleges, how does the gender gap in scientific degrees vary among two- and four-year college students? All of our analyses distinguish among scientific degree categories, to facilitate precision in interpreting sex segregation among distinct scientific disciplines.

Background / Context:

U.S. women now exceed men in university enrollment and degrees earned (e.g., DiPrete & Buchmann, 2013), and have achieved parity in some formerly male-dominated scientific fields, including biology and chemistry (Hill, Corbett, & St. Rose, 2010; U.S. Department of Labor, 2009). Meanwhile, women are still underrepresented in some STEM undergraduate degree fields, especially physical sciences, engineering, mathematics, and computer sciences (National Science Foundation, 2013). This pattern is not limited to the U.S. In Organization for Economic Co-operation and Development (OECD) member nations, women remain underrepresented in physical, engineering, mathematics, and computer science degrees (OECD, 2011). Alarmingly, while women have been earning more degrees in health fields, they are slipping in computing and technical degrees. The proportion of tertiary degrees earned in computing among OECD nations slipped from 23 percent of degree earners in 2000 to 19 percent in 2009; the U.S. witnessed a steeper slide, from 29 percent in 2000 to just 21 percent in 2009 (OECD, 2012).

The lack of gender parity in high-growth and high-earning fields like computing and engineering may have broader implications for women's economic futures. Notably, women tend to select degree fields with some of the lowest median earnings (Carnevale, Strohl, & Melton, 2011). Gendered variation in undergraduate field of study is a principal driver of income inequality, both indirectly through subsequent occupational choices and even directly, independent of work-related factors (Bobbitt-Zeher, 2007). As women are the primary earners for over 40 percent of U.S. households with children (Wang, Parker, & Taylor, 2013), the implications of the degree fields they choose and subsequent returns for their education have consequences for families and societies, as well as individual women.

Research explaining women's underrepresentation in the scientific labor force has focused on two issues: disparities in initial choice of a STEM major and persistence to degree. The dominant literature continues to argue for a "pipeline" to STEM fields, suggesting that young women move sequentially from secondary school courses to declaring and graduating with undergraduate degrees, into graduate school, and into the scientific community. This linear model appears overly simplistic, especially for less socioeconomically advantaged students (Goldrick-Rab, 2006) and women of color in STEM fields (Reyes, 2011). And yet, there are clear steps from high school through the college years that are critical to preventing talent loss among potential female scientists (e.g., Morgan, Gelbgiser, & Weeden, 2013 on the role of occupational plans). Ma's (2011) study of college students in the National Education Longitudinal Study of 1988 (NELS) cohort suggests that women are actually as likely as men to persist in STEM fields, if they select a STEM field upon matriculation; this decision appeared to be primarily affected by pre-college characteristics, such as attitudes about career, course taking, and achievement on science and math tests. These results stress the importance of considering pre-college and college characteristics while studying the gender gap in STEM, as well as examining STEM degree completion rather than initial major selection alone.

Setting:

We used the full panel of data from the Beginning Postsecondary Students (BPS) study of 2004-2009, a nationally representative, longitudinal study of first-time U.S. college students who first attended a postsecondary institution during the 2003–04 academic school year. Respondents were surveyed at the end of their first year and third year of college, and six years after first starting college.

Intervention / Program / Practice:

Women comprise 59 percent of two-year college students (Horn, Nevill, & Griffith, 2006). Intriguingly, some evidence suggests that college climates can have a "chilling" effect on students, cooling out their scientific ambitions (Hall & Sandler, 1984). This phenomenon is most commonly discussed regarding the climate of four-year institutions (e.g., Gayles & Ampaw, 2014; Hurtado, Eagan, Tran, Newman, Chang, & Velasco, 2011). It is less clear how two-year colleges affect women's persistence in STEM.

However, related studies suggest negative effects. In a study including 23 institutions, women in two-year colleges who perceived a chilly climate had weaker cognitive growth in scientific and other areas during their first year, as compared to their female peers in four-year colleges (Pascarella, et al., 1997). Reyes' (2011) study of women of color majoring in STEM found that the success rate of those who transfer from community colleges to four-year universities tended to encounter negative attitudes and treatment in these majors, perceived to be attributed to their ethnicity, gender, and challenges in the transfer status. These findings suggest that the increasing utilization of two-year colleges by U.S. students may actually exacerbate the gender gap in STEM majors.

To the best knowledge of the authors, there are to date no studies systematically comparing the effect of initial enrollment in two-year versus four-year colleges on the gender gap in scientific majors. As noted below, we employ propensity score matching and multinomial logistic regression models to compare this practice, in the context of increased interest in two-year colleges as a mechanism for decreasing inequalities in access to higher education.

Research Design:

To address potential selection effects, we employ a propensity score design to match respondents sharing a similar likelihood of attending a two-year college (the treatment variable). To match respondents, we used predictors distinct from those in our primary analytic models that are known to influence attending two-year rather than four-year institutions. These covariates were: family income percent rank in the 2003-04 school year, parental education level, immigrant status upon entering college, whether or not the respondent had earned college credits in high school, state-wide college going norms as measured by the percent of Bachelor's degrees earned in the state the student attended high school, high school type, and high school GPA. Respondents were matched based on these propensities, setting up a quasi-experimental comparison to assess the effect of initial enrollment in two-year colleges (vs. four-year colleges) on the gender gap in specific scientific fields. We included in our analyses those respondents who fell in a range of appropriate comparison. 6,767 people were matched on support, while 471 people were unmatched and dropped from the subsequent analysis.

Population / Participants / Subjects:

Our sample consists of women and men across race-ethnicity groups who complete a degree within six years after first starting college (2009). To ensure effective comparisons, we limit the study to traditional aged students who earned degrees. We therefore excluded respondents who were 24 years old and over at entry, non-completers, and those with undeclared majors. The 6,797 respondents matched in the propensity analysis constitute our analytic sample.

Data Collection and Analysis:

We used multinomial logistic regression to compare the predicted probabilities for men and women graduating with degrees in non-STEM fields as compared to the natural/engineering sciences, life sciences, and social/behavioral sciences. Response adjusted, calibrated bootstrap replicate weights for transcript respondents were used in our analyses, which were compared to and consistent with our unweighted results. We also employed survey weighting to adjust for stratification in the sample design. Additional sensitivity analyses were conducted to assess potential counterfactual explanations pertaining to socioeconomic status and degree type.

Findings / Results:

Since women and underrepresented minorities are more likely to attend two-year colleges (Horn, et al., 2006), it is important to consider the role these colleges play in affecting or maintaining the gender gap in natural/engineering sciences. To our knowledge, no study has used a longitudinal dataset to compare the effects of two-year and four-year college enrollment on the gender gap in STEM fields. Our study sought to address this by examining the role two-year colleges play in either decreasing or maintaining this gap. Overall, the results suggest that the gender gap in scientific degrees generally does not notably vary among two-year and four-year college enrollees. Indeed, college type only meaningfully affects the gender gap in life sciences degrees, favoring women. While both men and women are more likely to major in life sciences in two- compared to four-year colleges, women are even more likely to do so when they initially enroll in two-year institutions. Our results indicate that two-year colleges are not increasing parity in natural/engineering fields for women and underrepresented groups.

While this intriguing null result raises questions in and of itself, there were also notable patterns among other examined predictors of the gender gap. When examining race-ethnicity, we find that Asians had the largest gender gap in natural/engineering sciences at 20.6 percent. Latino students had the second highest gap at 17.6 percent followed by black students at 15.9 percent. Those who identified as other or multiracial had the lowest gender gap at 13.8 percent. These results suggest that men of all backgrounds are much more likely to major in natural/engineering sciences than women, but Asians and Latinos are especially contributing to this trend.

Results for pre-college characteristics are more mixed. Scoring in the top 25 percent in math on the SAT increased the probability for both men and women to major in natural and engineering sciences, and decreased the probability of graduating with a social and behavioral degree. Scoring in the top 25 percent on the verbal section of the SAT had the opposite effect, decreasing the chances of majoring in natural/engineering sciences and increasing the probability of obtaining a degree in social/behavioral sciences. This result is consistent with extant findings that a wider range of ability (in verbal as well as math) may influence young women's movement away from certain sciences (Wang, Eccles, & Kenny, 2013). However, neither Pell grant receipt nor completing more than Algebra II in high school significantly influenced the gender gap in natural/engineering sciences degrees. Notably, women completing more than Algebra II were more likely to pursue social/behavioral sciences over natural/engineering sciences, a finding contrary to expectation but consistent with recent work indicating that many mathematically talented girls drift from the "hard" sciences to the less sex-segregated social/behavioral sciences upon transitioning to college (Perez-Felkner, McDonald, Schneider, & Grogan, 2012).

With respect to college characteristics, students' integration on campus generated modest but intriguing findings. Social integration seemed to pull students into non-STEM majors from the sciences, but the attrition varied for men and women. Men left natural/engineering sciences while women left life sciences. It may be that for these largely laboratory-based sciences, time spent in labs conflicts with opportunities to participate in campus organizations, sports, and arts activities. With respect to the null effects of academic integration however, it is possible that the laboratory-based nature of undergraduate science courses, major advising, and the comparative availability of assistantship opportunities positions students in these majors to have less variance in faculty and study group contact than their peers in other majors. Finally, we find that STEM GPA does promote persistence in natural/engineering sciences degrees for women and men.

Conclusions:

Overall, the results suggest that the gender gap among two-year and four-year college students is not notably different. Future research should examine more carefully the undergraduate component of pipeline to STEM degrees and mechanisms to curb talent loss among women and underrepresented minorities, not only at four-year institutions but at two-year institutions as well. Given how little is known about STEM pipelines at two-year institutions, and policy levers directing students into these courses and majors, it is imperative to better understand the mechanisms for enhancing retention and persistence in STEM across institution types.

Appendices

Appendix A. References

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Appendix B. Tables and Figures

See tables on subsequent pages.

Table 1. Descriptive Statistics for Unmatched and Matched Samples, Beginning Postsecondary Students: 2004/2009

	Matched Sample (n=6,767)						Unmatched Sample (n=7,902)					
	Mean		SD		Range		Mean		SD		Range	
Independent Variables	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Demographic characteristics												
Race												
White	75.1%	72.8%	43.2%	44.5%	0-100%	0-100%	71.6%	70.3%	45.1%	46%	0-100%	0-100%
Asian	7.9%	9.5%	26.9%	29.3%	0-100%	0-100%	8.8%	10.6%	28.3%	31%	0-100%	0-100%
Black	6.9%	8.3%	25.4%	27.6%	0-100%	0-100%	8.4%	9.3%	27.8%	29%	0-100%	0-100%
Latino	5.1%	4.5%	22.0%	20.8%	0-100%	0-100%	6.1%	4.9%	23.9%	22%	0-100%	0-100%
Other / Multiracial	5.0%	4.8%	21.8%	21.4%	0-100%	0-100%	5.0%	4.9%	21.9%	22%	0-100%	0-100%
Pre-college characteristics												
Pell Grant Recipient	22.8%	27.1%	41.9%	44.5%	0-100%	0-100%	23.8%	29.2%	42.6%	45%	0-100%	0-100%
SAT Math Score	551.5	516.1	107.8	103.4	200-800	220-800	542.0	506.7	111.1	106.3	200-800	200-800
SAT Verbal Score	531.9	529.8	104.1	104.7	200-800	200-800	523.3	519.7	108.0	108.6	200-800	200-800
Highest level of H.S. math												
Less than Algebra II	4.3%	5.2%	20.3%	22.3%	0-100%	0-100%	6.0%	6.6%	23.8%	25%	0-100%	0-100%
Algebra II	18.6%	21.3%	38.9%	40.9%	0-100%	0-100%	19.5%	22.9%	39.6%	42%	0-100%	0-100%
More than Algebra II	77.1%	73.5%	42.0%	44.1%	0-100%	0-100%	74.5%	70.5%	43.6%	46%	0-100%	0-100%
College characteristics												
College STEM GPA												
No STEM GPA	17.1%	22.2%	37.7%	41.6%	0-100%	0-100%	16.7%	21.8%	37.3%	41%	0-100%	0-100%
Less than 3.0	51.4%	45.7%	50.0%	49.8%	0-100%	0-100%	52.6%	46.8%	49.9%	50%	0-100%	0-100%
More than 3.0	31.5%	32.1%	46.5%	46.7%	0-100%	0-100%	30.7%	31.5%	46.1%	46%	0-100%	0-100%
Initial Enrollment Type												
Two-year college	14.8%	17.7%	35.6%	38.2%	0-100%	0-100%	22.1%	23.8%	41.5%	43%	0-100%	0-100%
Four-year college	85.2%	82.3%	35.6%	38.2%	0-100%	0-100%	77.9%	76.2%	41.5%	43%	0-100%	0-100%

Academic integration index	86.3	89.9	41.8	42.0	0-200	0-200	84.2	87.7	42.4	42.7	0-200	0-200
Social integration index	67.3	62.3	53.7	53.4	0-200	0-200	63.2	58.8	53.6	53.5	0-200	0-200

Source: Beginning Postsecondary Students Study: 2004 to 2009. Figures are rounded to the nearest tenth in accordance of NCES restricted data use confidentiality procedures.

Note: Data are based on unweighted counts. There were 1,135 unmatched cases in the propensity score match that were dropped from the analysis. Bonferroni tests were conducted to evaluate gender differences in these results. Significance indicators are not shown because of space constraints, however these results are available by request from the authors.

Table 2. Descriptive Statistics for Matched Sample, Beginning Postsecondary Students

	Matched Sample (n=6,767)					
	Mean		SD		Range	
Dependent Variable	Men	Women	Men	Women	Men	Women
Major (2009)						
Non-STEM	55.9%	54.7%	49.7%	49.8%	0-100	0-100
Natural / Engineering Sciences	20.4%	5.0%	40.3%	21.7%	0-100	0-100
Life Sciences	10.3%	22.4%	30.4%	41.7%	0-100	0-100
Social / Behavioral Sciences	13.5%	18.0%	34.1%	38.4%	0-100	0-100

Source: Beginning Postsecondary Students Study: 2004 to 2009. Figures are rounded to the nearest tenth in accordance of NCES restricted data use confidentiality procedures.

Notes: Data are weighted, using replicate weights. Difference between unmatched and matched sample cannot be seen until rounding to the second decimal place.

Table 3. Degree Attainment among College Graduates, by Scientific Field

	Degree field							
	Non-STEM (reference)		Natural / Engineering Sciences		Life Sciences		Social / Behavioral Sciences	
Predictors	Men	Women	Men	Women	Men	Women	Men	Women
Background characteristics								
Women (men=reference)	0.552	0.554	0.213***	0.048***	0.104***	0.222***	0.131**	0.176**
	(.014)	(.011)	(.010)	(.004)	(.008)	(.010)	(.011)	(.008)
Race-ethnicity (white=reference)								
Asian or Asian American	0.556	0.557	0.216***	0.048***	0.109***	0.234***	0.119*	0.160*
	(.030)	(.029)	(.029)	(.009)	(.018)	(.029)	(.021)	(.027)
Black	0.587	0.595	0.202***	0.046***	0.090***	0.195***	0.120*	0.164*
	(.031)	(.027)	(.031)	(.009)	(.017)	(.027)	(.018)	(.021)
Latino	0.392	0.399	0.310***	0.070***	0.153***	0.332***	0.146*	0.199*
	(.037)	(.035)	(.046)	(.016)	(.025)	(.039)	(.025)	(.030)
Other / Multiracial	0.543	0.514	0.184***	0.039***	0.135***	0.273***	0.138	0.175
	(.039)	(.042)	(.031)	(.008)	(.026)	(.042)	(.028)	(.031)
F -Statistic	19.240 ***							

Note: Significance denotes a significant difference between men and women in each category.
*p < .05 **p < .01 ***p < .001 (two-tailed tests).

Table 4. Predicted Probabilities for Scientific Degree Attainment among College Graduates by Field

	Degree field (n=6,767)							
	Non-STEM (reference)		Natural / Engineering Sciences		Life Sciences		Social / Behavioral Sciences	
Independent Variables	Men	Women	Men	Women	Men	Women	Men	Women
Demographic characteristics								
Main effect of female gender	0.564	0.551	0.198***	0.051***	0.104***	0.224***	0.134**	0.175**
	(.014)	(.011)	(.011)	(.005)	(.008)	(.009)	(.011)	(.008)
Race-ethnicity								
White (reference)								
Asian	0.480	0.501	0.287***	0.081***	0.102***	0.236***	0.131*	0.183*
	(.034)	(.032)	(.037)	(.017)	(.017)	(.030)	(.024)	(.031)
Black	0.562	0.569	0.217***	0.058***	0.086***	0.191***	0.135*	0.182*
	(.032)	(.029)	(.032)	(.012)	(.017)	(.027)	(.020)	(.024)
Latino	0.440	0.412	0.234***	0.058***	0.152***	0.312***	0.174	0.218
	(.038)	(.036)	(.037)	(.013)	(.027)	(.041)	(.030)	(.035)
Other / Multiracial	0.541	0.504	0.182***	0.044***	0.136***	0.277***	0.141	0.175
	(.039)	(.043)	(.031)	(.010)	(.027)	(.044)	(.029)	(.032)
Pre-College characteristics								
Pell grant recipient 2003-04								
No, did not receive Pell (reference)	0.565	0.554	0.198***	0.051***	0.102***	0.219***	0.135*	0.176*
	(.015)	(.012)	(.011)	(.005)	(.008)	(.010)	(.012)	(.009)
Yes, received Pell	0.559	0.542	0.198***	0.050***	0.112***	0.239***	0.131*	0.169*
	(.021)	(.018)	(.022)	(.006)	(.011)	(.016)	(.014)	(.013)
SAT math score (top 25%)	0.497	0.513	0.270***	0.072***	0.110***	0.248***	0.123**	0.167**
	(.016)	(.016)	(.013)	(.008)	(.009)	(.015)	(.011)	(.009)
SAT verbal score (top 25%)	0.561	0.540	0.181***	0.046***	0.101***	0.213***	0.157**	0.201**

	(.016)	(.540)	(.012)	(.004)	(.009)	(.010)	(.014)	(.010)
Highest level of high school math completed								
Less than Algebra II (reference)								
Algebra II	0.597	0.558	0.147***	0.036***	0.111***	0.227***	0.144	0.179
	(.043)	(.038)	(.038)	(.011)	(.019)	(.031)	(.030)	(.031)
More than Algebra II	0.570	0.553	0.190***	0.049***	0.104***	0.222***	0.136*	0.176*
	(.019)	(.015)	(.013)	(.005)	(.009)	(.013)	(.014)	(.011)
College characteristics								
College STEM GPA								
Less than 3.0 (reference)								
More than 3.0	0.541	0.541	0.232***	0.061***	0.110***	0.215***	0.117**	0.157**
	(.022)	(.016)	(.019)	(.007)	(.010)	(.011)	(.018)	(.014)
No STEM GPA	0.564	0.551	0.198***	0.051***	0.103***	0.221***	0.135*	0.177*
	(.022)	(.021)	(.021)	(.007)	(.013)	(.022)	(.018)	(.017)
Academic integration index	0.560	0.545	0.197***	0.050***	0.107***	0.228***	0.137**	0.178**
	(.015)	(.011)	(.011)	(.005)	(.009)	(.010)	(.012)	(.008)
Social integration index	0.589	0.572	0.176***	0.045***	0.096***	0.204***	0.139**	0.180**
	(.014)	(.014)	(.012)	(.004)	(.008)	(.011)	(.012)	(.010)
Initial Enrollment Type								
Two-year college	0.545	0.516	0.201***	0.050***	0.140***	0.291***	0.114*	0.144*
	(.028)	(.023)	(.024)	(.008)	(.018)	(.026)	(.025)	(.023)
Four-year college	0.569	0.562	0.198***	0.051***	0.094***	0.205***	0.138*	0.182*
	(.015)	(.013)	(.012)	(.005)	(.007)	(.010)	(.010)	(.010)
F-Statistic	12.090 ***							

Note: Significance denotes a significant difference between men and women in each category.
*p < .05 **p < .01 ***p < .001 (two-tailed tests).

Table 5. Gender Gap in Two-Year colleges in the Probability of Earning Degrees in Specific Scientific Fields, By Race-Ethnicity

	Probability Difference (n=6,767)		
Group category	Natural / Engineering Sciences	Life Sciences	Social / Behavioral Sciences
Two-year colleges, gender diff.			
All students	-0.151	0.151	0.030
White students (reference)			
Asian students	-0.211	0.168	0.039
Black students	-0.164	0.135	0.036
Latino students	-0.178	0.194	0.028
Other/multiracial students	-0.140	0.173	0.022

Note: The gender gap is calculated as the difference between women's and men's chances of earning degrees in these fields. Specifically, the probability for men is subtracted from the probability for women. *n = 2,769 for men, n = 3,998 for women.*
 * p <.05, ** p <.01, *** p<.001 (two-tailed tests).

Table 6. Gender Gap in Probability of Degree, by College Type (n=6,767)

College Type	Non-STEM	Natural and Engineering Sciences		Life Sciences		Social and Behavioral Sciences	
Two-year college	-0.030	-0.151	***	0.151	***	0.030	*
Four-year college	-0.008	-0.146	***	0.111	***	0.043	*

Note: The gender gap within college types is measured as $Probability_{women}$ - $Probability_{men}$. Bonferroni tests were used to compare the significance of the differences of these predicted effects.
* p <.05, ** p <.01, *** p<.001 (two-tailed tests).

Table 7. Difference by College Type in Probability of Degree, by Gender

	Difference in Probability of Degree (n=6,767)				
Gender	Non-STEM	Natural and Engineering Sciences	Life Sciences		Social and Behavioral Sciences
Men	0.024	-0.003	-0.045	*	0.024
Women	0.046	0.002	-0.085	*	0.038

Note: College type difference is measured as $Probability_{4\text{-}year}$ - $Probability_{2\text{-}year}$. Bonferroni tests were used to compare the significance of the differences of these predicted effects.
* p <.05, ** p <.01, *** p<.001 (two-tailed tests).