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# Does Adding ”Helping Disciplines” to Engineering Schools Contribute to Gender Parity?

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## Introduction

There is persistent gender disparity in engineering, with women making up only about 26% of engineering undergraduate students in the United States in 2018[1]. However, there are dramatic differences by discipline in the participation of women, with some traditional engineering disciplines (mechanical, electrical) having relatively low undergraduate numbers (single digits at some institutions), while other, often newer, programs like biomedical (BME) and environmental (ENV) reach near parity in some schools. BME and ENV are often viewed as "helping" disciplines, which suggests why they may be more appealing to women students. Research conducted as a means of evaluating a NSF project to attract more women to engineering shows that young women are attracted to "helping" disciplines within engineering[2]. Anecdotal evidence from one institution suggests adding a "helping" discipline may be associated with a decline in the proportion of women in a related traditional discipline (that is, the new disciplines may attract women already in the engineering pipeline, rather than attracting women to engineering who would not otherwise be enrolled).

Our research question is: what is the impact of adding women-associated "helping" disciplines (BME and ENV) on the percentage of women undergraduate students enrolled at an engineering school as a whole and within traditional disciplines at that school?

## Background

Social psychology research distinguishes between careers perceived to meet communal goals—often defined based on their benefit to other people—and careers believed to align with more individualistic, agentic goals. This distinction is significant because a) there is a perceived disassociation between STEM fields and communal goals, and b) women are more likely than men to endorse communal goals[3,4]. The stereotypes women and girls hold about the nature of engineering work, including the values of the field, have been shown to influence their choice to enter the field[5]. Conforming to gender scripts around interests and passions, particularly around women as helpers and men as technically masterful, is a way for both men and women to reinforce their gender identity[6].

Sex segregation of the labour market is a world-wide phenomenon, with female representation in engineering in particular being negatively correlated to GDP, suggesting that as women gain access to more educational and occupational opportunities, they increasingly conform to stereotypical gender roles and expectations[7]. Sociologists distinguish between gender essentialism, which is the idea that there are innate differences in capacities based on gender, and gender as a social construction, which emphasizes that gender roles are learned through socialization processes. Butler[8] and West and Zimmerman[9] argue that women and men are performing or "doing" gender, and exercise their agency in deploying both gender conforming behaviours and non-conforming behaviours strategically. However, there are limits to this agency, as women are unable to dismantle or challenge the underlying gender structure of the workplace. For example, research by Powell et al.[10] shows how women engineers conform to gender stereotypes while also strategically engaging in "anti-women" behaviours, but in these actions they are reproducing the environment that is hostile to them in the first place. Similarly, the creation of women-friendly groups within engineering programs provides support to women, but does not provide a direct challenge to the overall environment that produces a need for this support.

Young women considering engineering are aware that they are entering a male-dominated field and that there are significant efforts to attract women[2]. Young women engineers who participated in an NSF funded project, Female Recruits Explore Engineering, were interviewed to see how recruitment efforts directed towards bringing more women into engineering affected their choice of discipline[2]. Their study showed that young women were cognizant that they were entering a male-dominated field and that there were concerted efforts to bring more women into these fields. They also were aware that materials were designed to showcase women in engineering, and alert them to the challenges that engineering would bring. Overall women were attracted to "helping" disciplines within engineering, however there was a class and race component to this: white affluent women were more likely to express a conscious intent to gain technical knowledge and to work in non-"helping" fields, while people of colour and less affluent women were more likely to be attracted to "helping" (while simultaneously expressing concerns about engineering being too time-demanding for their child-rearing goals). Women in this study were also aware, through their own experiences with engineering camps and clubs and through talking to professional women with engineering degrees as part of the NSF program, that they would be encouraged to take on managerial roles within projects, as they were both viewed as more competent in the people-skills necessary for these roles, and that strategically these roles offered more flexibility in terms of balancing work and family demands.

While empirical research has considered differences between STEM fields with regard to numerous perceived gendered factors, such as masculine stereotypes and alignment with normative gender behavior[11,12], much of this work treats engineering as a relatively homogenous field, leaving room for further consideration of perceived differences between engineering disciplines (e.g. electrical engineering versus chemical engineering). The question of engineering disciplines is particularly salient given women's different rates of enrollment between, for example, computer (11.3% women) and environmental (45.2% women) engineering.

Outside of engineering, women tend to be overrepresented in communal or "helping" fields, such as work perceived to be care-related in education (e.g. preschool teaching) and health care (e.g. nursing)[13]. The same process may be occurring within engineering itself. Disciplines such as BME and ENV are framed with a "concrete and explicit intention to help -- rather than simply to advance knowledge or technology"[14]. While not necessarily more helpful than other disciplines in actual outputs, these newer and interdisciplinary specializations are *presented* as being tied directly to health and environmental benefits that can have lasting impacts for individuals and community—framing shown to align with women's career planning.

Given the theory behind women preferentially choosing "helping" disciplines, and the suggested possibility of increasing the percentage of women in engineering through emphasis on communal goals, we assess the short-term impact of adding women-associated "helping" disciplines to engineering schools across the US.

**Methods**
We collected undergraduate enrollment data by gender for US engineering schools from the ASEE (American Society for Engineering Education) College Profiles for the years 2005-2017[15]. Data was available from 362 schools, although not all schools had data for all years.

We assumed that BME and ENV programs were added to a school in the first year after 2005 having enrollment data in either discipline. We had to discard BME and ENV programs with enrollment data that first appeared in 2005, because it was not known from this data set if the programs had started in that year or if they had started earlier.

To determine the change in undergraduate enrollment with the introduction of the new programs, we examined the enrollment at two time points: one year before and three years after the new program first had enrolled students. We expected that it may take a few years for a new program to become known, and to influence the educational choices of students in that school. As a result, we could only examine schools where the BME or ENV program started before 2015.

We chose four traditional disciplines with a range of female enrolments (12.6% to 33.6%) to examine for changes: chemical engineering (CHEM), mechanical engineering (MECH), electrical engineering (ELEC), and civil engineering (CIVL) (Table 1). These are the four largest disciplines, with total undergraduate enrollment among them making up nearly half of all US engineering students. Because of their large size, about 44% of all female undergraduate engineering students in the US are enrolled in these disciplines. However, these traditional disciplines are still highly male-dominated, with an enrollment of less than 18% women overall.

Table 1: Distribution of total and female undergraduate enrollment among disciplines, and distribution of female enrollment within disciplines, for all disciplines examined in this study. Enrollment for all years (2005-2017) at 362 US schools was included.

| Discipline | | Percentage of US eng. students in discipline out of total US eng. students | Percentage of US female eng. students in discipline out of total US female eng. students | Percentage of students within discipline who are female |
|---|---|---|---|---|
| Traditional Disciplines | | | | |
| Chemical | CHEM | 7.5% | 12.8% | 33.6% |
| Mechanical | MECH | 21.9% | 13.9% | 12.6% |
| Electrical | ELEC | 9.7% | 6.1% | 12.3% |
| Civil | CIVL | 10.3% | 11.5% | 22.0% |
| **Overall Traditional** | | **49.4%** | **44.3%** | **17.7%** |
| “Helping” Disciplines | | | | |
| Biomedical | BME | 4.8% | 10.2% | 42.0% |
| Environmental | ENV | 0.7% | 2.1% | 45.2% |
| **Overall “Helping”** | | **5.7%** | **12.4%** | **42.5%** |

We also noted that while the “helping” disciplines have a high proportion of women students (42.5%), their total population is small, with less than 6% of all engineering students enrolled in these disciplines (Table 1).

We examined changes in the traditional disciplines as well as the overall change in undergraduate enrollment of the schools with the addition of BME or ENV. Due to the overall increase in the proportion of women in engineering over time, and the range of different years when programs were introduced, we also needed to account for the timing of those introductions. As a result, we examined both the absolute and relative (to national proportion in that particular year) changes in the enrollment of women. Because the smallest schools were often outliers in terms of proportion of women (since a small number of women joining or leaving can lead to a large change in proportion), we eliminated schools with an average overall enrollment of less than 500 students in the years before and after a “helping” discipline was introduced.

Paired t-tests were performed to examine the changes in the proportion of women in each traditional discipline program with the addition of BME or ENV, both in absolute terms and relative to the national average in that year. Paired t-tests were also used to determine the overall change in proportion of women at a school, both in absolute terms and relative to the national average in that year. We additionally considered the overall enrollment changes with and without inclusion of the “helping” disciplines BME and ENV.

We also performed linear mixed model testing to examine if the changes with the addition of BME or ENV depended on the size of school. The included schools were divided into ‘small’ if they had an overall enrollment of less than the median of the included schools, and ‘large’ otherwise. School size was considered a fixed effect, while school was a random effect (that is, the individual characteristics of a school were likely different from each other, even within size groupings). Testing was performed for four cases: the difference in proportion and relative proportion of female students with the addition of either BME or ENV.

All statistical testing was completed using STATA 13 (StataCorp, College Station, TX).

**Results**

We found that 45 schools added BME programs in our time window, and 18 schools added ENV programs in our time window (out of a total of 141 schools with BME programs and 100 schools with ENV programs). However, only 38 (BME) and 16 (ENV) schools also had at least one of the traditional disciplines. In three cases, the data for one traditional discipline was only available at one of the two time points (one CIVL and two ELEC programs), so these were removed. Six (6) schools had enrollments of under 500 students, and were all schools that had introduced BME programs – these were removed from the analysis. The final totals were 32 schools introducing BME, and 16 introducing ENV (see Appendix A for a complete list).

Two schools introduced both BME and ENV in the same year (Ohio State, California State University – Long Beach). These were noted, but the effects could not be decoupled and the additions were treated independently. There were no other overlaps in the 4-year period examined for each addition, although Clemson added both programs with a gap of 8 years.

The following figures show the results per program following the addition of BME – proportion (Figure 1) and relative proportion (Figure 2) – and following the addition of ENV – proportion (Figure 3) and relative proportion (Figure 4).

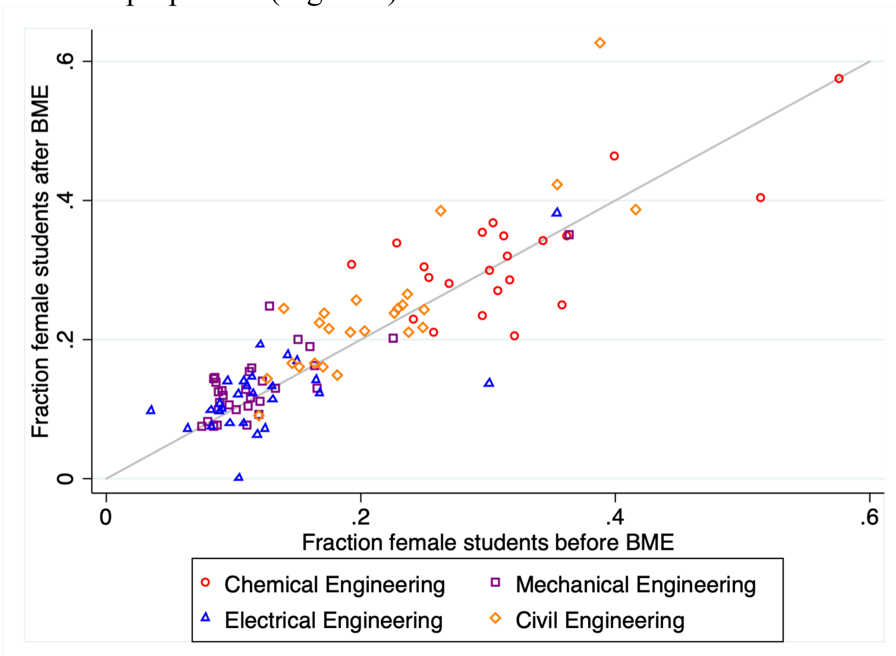


Figure 1: Plot of fraction of female undergraduate students before BME program added and fraction of female undergraduate students after BME program added, by discipline. The grey line shows no change before and after "helping" program added.

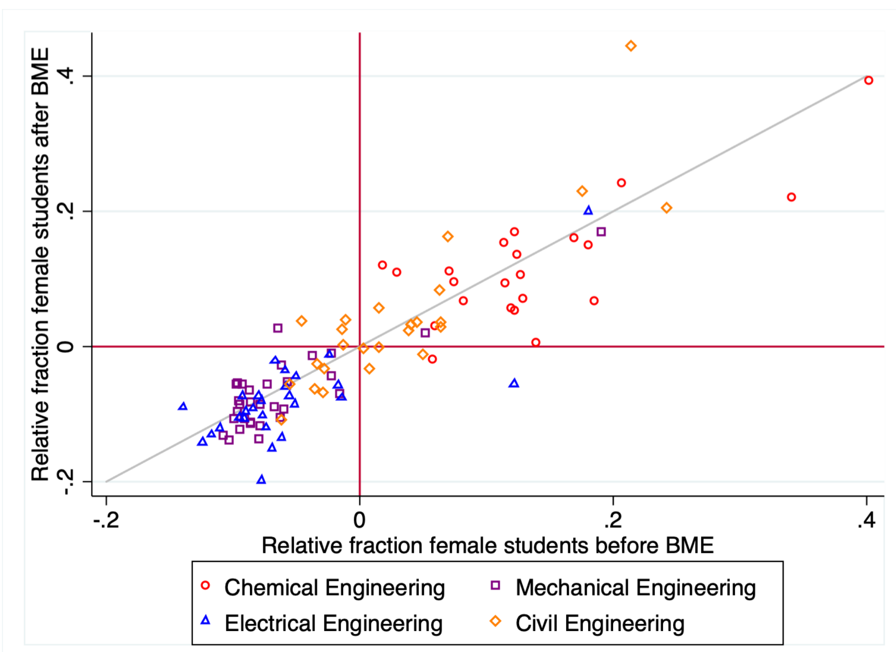


Figure 2: Plot of relative fraction of female undergraduate students before BME program added and relative fraction of female undergraduate students after BME program added, by discipline. Fractions are relative to the overall fraction of female undergraduate students in all US schools for the year examined in each case. Vertical and horizontal lines indicate the overall US average

proportion of female undergraduate students. The grey line shows no change before and after "helping" program added.

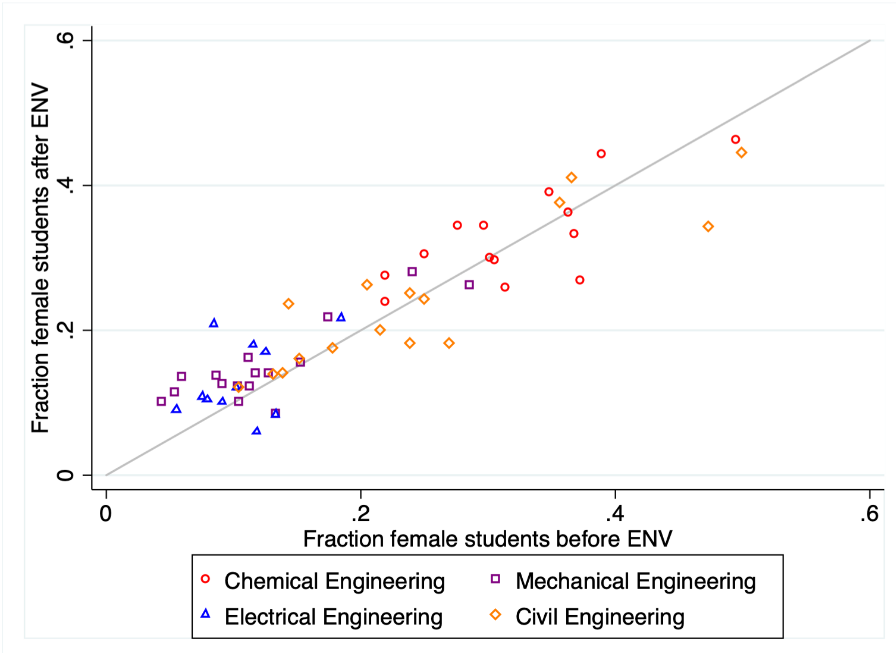


Figure 3: Plot of fraction of female undergraduate students before ENV program added and fraction of female undergraduate students after ENV program added, by discipline. The grey line shows no change before and after "helping" program added.

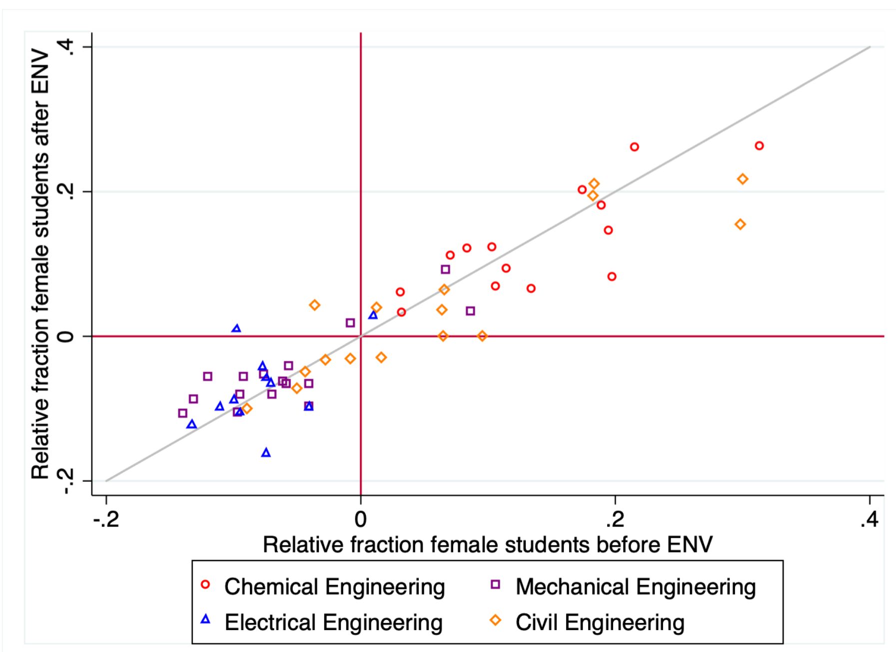


Figure 4: Plot of relative fraction of female undergraduate students before ENV program added and relative fraction of female undergraduate students after ENV program added, by discipline. Fractions are relative to the overall fraction of female undergraduate students in all US schools for the year examined in each case. Vertical and horizontal lines indicate the overall US average

proportion of female undergraduate students. The grey line shows no change before and after "helping" program added.

It may be observed from Figure 2 and Figure 4 above that the disciplines have different typical rates of female enrollment, with CIVL and CHEM having higher rates (often above the national average), and MECH and ELEC having lower rates (often below the national average).

Paired t-tests show that, if considering the absolute proportion of female students, statistically significant increases occurred in MECH with the addition of both BME and ENV programs, and statistically significant increases occurred in CIVL with the addition of BME (Table 2). For example, the initial mean percentage of women in MECH was 12.18% before BME was added in the included schools, and the mean percentage of women in MECH was 13.49% after BME was added, with a difference of +1.31%.

However, when considered relative to the overall increase in proportion of female engineering students over time, the only statistically significant change was a *decrease* in ELEC with BME (Table 2). The largest percent changes in the traditional disciplines were negative, when considered relative to US proportions in the years examined. Note that this data is independent between disciplines – conservative corrections for multiple testing (relative and absolute tests) may be made by comparing results to $\alpha = 0.025$, in which case only MECH with ENV (absolute) and ELEC with BME (relative) remain significant.

Table 2: Results of paired t-test comparing proportion of female undergraduate students enrolled in each of the traditional disciplines (CHEM, MECH, ELEC, CIVL) following the introduction of BME or ENV, including both the absolute and relative proportions.

| Discipline | Change in percentage women | | | | Change in percentage women relative to US overall | | | |
|---|---|---|---|---|---|---|---|---|
| | BME added | | ENV added | | BME added | | ENV added | |
| | Change | *p*-value | Change | *p*-value | Change | *p*-value | Change | *p*-value |
| CHEM | -0.08% | 0.956 | +0.66% | 0.632 | -1.92% | 0.170 | -1.16% | 0.389 |
| MECH | **+1.31%** | **0.037*** | **+2.47%** | **0.009*** | -0.61% | 0.312 | +0.64% | 0.453 |
| ELEC | -0.38% | 0.697 | +2.46% | 0.132 | **-2.25%** | **0.024*** | +0.47% | 0.760 |
| CIVL | **+2.75%** | **0.030*** | -0.73% | 0.599 | +0.83% | 0.503 | -2.56% | 0.076 |

Paired t-test results on overall school data show that absolute proportions of women at a school increase with the introduction of BME and ENV (Table 3). For example, the percentage of female students was 17.69% before the addition of BME (overall included schools), and increased to 20.56% after the addition of BME, for a difference of +2.87%. But when removing the effect of the overall increase in women nationally, relative proportions increase by a much smaller amount if considering the overall school, but *decrease* if BME and ENV programs are excluded from the totals (statistically significant for BME; Table 3). (Note that even with conservative corrections for multiple comparisons, all significant results remain significant.)

Table 3: Results of paired t-test comparing proportion of female undergraduate students enrolled in the school (total, and excluding BME and ENV from total) following the introduction of BME or ENV; both the absolute and relative proportions.

| Metric | Change in percentage women | | | | Change in percentage women relative to US overall | | | |
|---|---|---|---|---|---|---|---|---|
| | BME added | | ENV added | | BME added | | ENV added | |
| | Change | *p*-value | Change | *p*-value | Change | *p*-value | Change | *p*-value |
| Overall school | **+2.87%** | **0.000*** | **+2.09%** | **0.000*** | **+0.98%** | **0.001*** | +0.23% | 0.483 |
| Overall school excluding ENV and BME | **+0.92%** | **0.001*** | **+1.59%** | **0.000*** | **-0.98%** | **0.000*** | -0.27% | 0.401 |

The included schools were, on average, below the national average for percentage of women enrolled (-0.69%) prior to BME, and above the national average (+0.29%) after adding BME. Schools that added ENV were already above the national average for percentage of women enrolled prior to starting that program (+2.05%), and further increased after adding ENV (+2.28%).

Finally, we performed linear mixed model testing to determine if school size impacted the overall results (Table 4). The median for overall enrollment in the included schools was 2016 students, which was the dividing line between large (2059-7882 students) and small (534-2016 students) schools. Differences between before and after the addition of each "helping" discipline were found, and normality testing indicated these values were normally distributed (see Appendix B). There were no differences based on school size ($p > 0.5$). Additionally, the variabilities between schools (random effects) were an order of magnitude smaller than the non-significant differences based on school size (e.g. 0.011% variability is on the order of 10 times smaller than the 0.83% value for large schools). This low variability indicates that the impact of the unique school-to-school differences in characteristics on changes in the proportion of female students is negligible.

Table 4: Results of linear mixed model analysis, showing the female undergraduate enrollment levels for large and small schools (absolute and relative (to national) proportions of female undergraduate students), as well as the variability in female undergraduate enrollment between schools.

| Discipline Added | School size differences | | | | | | Variability between schools | |
|---|---|---|---|---|---|---|---|---|
| | Diff in percentage women | | | Diff in relative (to US overall) percentage women | | | | |
| | Large school | Small school | *p*-value | Large school | Small school | *p*-value | Diff in percentage | Diff in rel. perc. |
| BME | +1.11% | +0.79% | 0.788 | -0.24% | -1.07% | 0.841 | 0.049% | 0.045% |
| ENV | +0.83% | +1.42% | 0.545 | +0.35% | -0.59% | 0.780 | 0.011% | <0.001% |

**Discussion**

We found that, when considered relative to the increasing trend of the national average, adding BME to a school led to a statistically significant reduction in the proportion of women undergraduates enrolled in ELEC (-2.3%, $p < 0.025$). While not statistically significant, we also saw a trend showing that adding ENV resulted in a decrease in the proportion of women undergraduates enrolled in CIVL (-2.6%, $p = 0.08$). These specific reductions make sense with the hypothesis that the new disciplines poach women with similar interests from the traditional disciplines, because CIVL and ENV are closely-related disciplines (sometimes even combined into joint programs), and ELEC can also be closely related to BME, depending on the BME program specifics. Women students who would otherwise be interested in these particular traditional disciplines might choose the related "helping" discipline, if available.

The relative increase in the overall proportion of women undergraduates enrolled at the schools examined is clearly driven by the BME and ENV programs. Without considering BME or ENV, there is a relative decrease in the percentage of women undergraduates enrolled at the schools with the addition of either "helping" discipline (-0.98%, $p < 0.001$). This relative decrease in female undergraduate enrollment outside of these two disciplines implies that women who might otherwise go into other disciplines (some of which may not be captured in the limited set of traditional disciplines examined here) are going into BME and ENV, even as the "helping" programs attract more women to enroll in engineering overall than if the programs did not exist (relative +0.98%, $p = 0.001$).

Increasing the number of women in "helping" disciplines (BME, ENV) alone is unlikely to drastically change the gender imbalance in engineering because the total number of jobs in those disciplines is lower than in the traditional disciplines. Based on US Bureau of Labor Statistics data, only 2% of all working engineers are in BME and ENV combined[16]. If somehow women took over these fields entirely (100% women in BME and ENV), we would have a working engineer population of 15.6% women instead of 14.0% women. This analysis indicates that engineering schools will not change the larger face of engineering through attracting women to newly-added "helping" disciplines alone. To have a measurable shift in the overall proportion of women in engineering, women must join the traditional disciplines as well. As a result, the impact of these programs on the undergraduate enrollment of women in traditional disciplines is likely more important than an overall increase in the percentage of enrolled undergraduate women driven by the addition of "helping" disciplines.

This research also raises questions about the connection between gender parity in students' engineering education and in their future engineering employment. Although the data presented here only address gender trends in short term enrollments, the long term benefits of women amassing higher numbers in engineering's "helping" disciplines are provisional, since feminized fields tend to be devalued with regard to status and pay[17]. Future research may consider connections between engineering's "helping" disciplines and employee salary and gender. Given that data shows people of colour and women from lower socioeconomic backgrounds are more likely to indicate interest in "helping" professions[2], future work may also document intersections between these variables.

At the same time, this research points to the need for potential alternatives to the framing of certain engineering disciplines as more altruistic or communal than others. To work toward gender parity, Diekman et al. suggest "interventions… [to] demonstrate how STEM fields involve "helping" and collaborating with other people" as a way to increase the involvement of women and communal-minded people in STEM more generally[4]. One potential strategy may be for engineering programs to highlight that many disciplines within engineering have the potential to meet communal goals, moving beyond those already seen to be female-dominated. This signalling would be possible to implement through public-facing documents such as program promotional materials that already tend to frame engineering in particular ways through language choices[18].

An important finding for future work in this area is that the background change in the percentage of women undergraduates enrolled in engineering nationally is substantial enough to impact results when examining factors that influence women's decisions around enrolling. This increasing trend over time must be accounted for in any assessment of programs to increase the enrollment of undergraduate women in engineering.

Strengths of this work include using a natural experiment to determine how women might be attracted to "helping" disciplines, which allowed a broad examination of the effects on undergraduate enrollment. Limitations of this work include limitations of the data, such as missing data for some schools, year, or programs. There may also be differences in the specific content of the "helping" programs. BME in particular has a wide variety of content – some programs may overlap more with MECH, while others may overlap more with ELEC. If BME was diverting students from traditional disciplines, the particular discipline that was most affected may differ between schools. Another potential challenge is that schools with common years (1 or 2) may have attracted students based on a new program that did not have enrollees yet, which could impact the overall undergraduate school enrollment values before the program introduction. Some schools have joint Electrical/Computer or Civil/Environmental programs, which had to be neglected – it is unclear what the impact of this might be on the results.

Overall this research suggests that the addition of "helping" disciplines to a school is an insufficient approach to addressing gender imbalance in engineering education. While there is evidence that the "helping" disciplines, BME and ENV, do attract women to engineering schools, they may have a negative impact on the enrollment of women in other disciplines (especially related traditional disciplines) at the same schools. Reaching gender parity will not be possible by simply encouraging women to join "helping" disciplines, both because of this effect on the much larger traditional disciplines and because BME and ENV comprise such a minor share of both the undergraduate enrollment and the workforce in engineering. Positioning other engineering disciplines as communal or "helping" may be a more effective strategy for ultimately attaining a distribution of gender within engineering that reflects the larger community.

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## Appendix A – Included schools

Table 5: Schools included in this analysis, including mean enrollments (with and without BME/ENV), the first years BME and ENV had enrollees, and school size (S = small, L = large).

| School | School full-time enrollment (mean over years considered) | | First year BME | First year ENV | Size (S or L) |
|---|---|---|---|---|---|
| | All disciplines | All disciplines except BME and ENV | | | |
| California Polytechnic State University-San Luis Obispo | 5134 | 4750 | 2006 | | L |
| California State University-Long Beach | 2896 | 2826 | 2011 | 2011 | L |
| City College of the City University of New York | 1710.5 | 1565 | | 2006 | S |
| Clemson University | 4019.75 | 3795.25 | 2006 | 2014 | L |
| Colorado State University | 1930 | 1713.5 | 2010 | | S |
| Columbia University | 1442.5 | 1331.5 | | 2010 | S |
| Duke University | 1248.5 | 962.5 | | 2014 | S |
| Florida Institute of Technology | 1614 | 1565.5 | 2012 | | S |
| Florida International University | 1768.5 | 1607 | | 2006 | S |
| George Mason University | 2241 | 2164 | 2010 | | L |
| Georgia Institute of Technology | 7272 | 6311.5 | | 2007 | L |
| Massachusetts Institute of Technology | 1795 | 1704.5 | 2006 | | S |
| Michigan State University | 4011 | 3943 | | 2011 | L |
| NYU Tandon School of Engineering | 1578 | 1518.5 | 2013 | | S |
| Purdue University | 7882 | 7588 | | 2013 | L |
| Rochester Institute of Technology | 2589 | 2494.5 | 2010 | | L |
| Rowan University | 1087 | 1006 | 2014 | | S |
| Rutgers-The State University of New Jersey-School of Engineering | 2742 | 2419.5 | | 2008 | L |
| San Jose State University | 2693 | 2637 | 2012 | | L |
| Santa Clara University | 764 | 694 | 2009 | | S |
| Stanford University | 2414 | 2404 | | 2008 | L |
| Temple University | 1304 | 1166.5 | 2013 | | S |
| Texas A&M University - Kingsville | 732 | 716.5 | | 2009 | S |
| The Ohio State University | 5957 | 5629.5 | 2009 | 2009 | L |
| The University of Texas at Arlington | 2199.5 | 2115 | 2012 | | L |
| The University of Texas at Dallas | 2058.5 | 1874.5 | 2011 | | L |
| The University of Texas at San Antonio | 2016 | 1968 | 2011 | | S |
| Trine University | 633.5 | 597 | 2014 | | S |
| Tufts University | 713 | 670 | 2006 | | S |
| University at Buffalo-SUNY | 2666 | 2443 | 2010 | | L |
| University of Arizona | 2452 | 2354.5 | 2010 | | L |
| University of Arkansas | 2500 | 2413 | 2012 | | L |
| University of California-Riverside | 1611.5 | 1353 | 2008 | | S |
| University of Cincinnati | 3036.5 | 2711 | | 2012 | L |
| University of Colorado Denver | 533.5 | 509 | 2014 | | S |
| University of Delaware | 2185 | 1961 | 2012 | | L |
| University of Florida | 5618 | 5265 | 2012 | | L |
| University of Maryland-College Park | 2692 | 2604 | 2006 | | L |
| University of Michigan-Dearborn | 990 | 931 | 2012 | | S |
| University of New Haven | 545.5 | 545.5 | | 2013 | S |
| University of South Carolina | 1278.5 | 1212 | 2006 | | S |
| University of Wyoming | 1245.5 | 1243.5 | 2009 | | S |
| Vanderbilt University | 1272 | 928 | | 2006 | S |
| Wayne State University | 818.5 | 772.5 | 2010 | | S |
| Wichita State University | 1389.5 | 1315 | 2011 | | S |

## Appendix B – Normality assumption checking

Shown below are the Q-Q plots used for checking the normality assumption of the proportion differences before and after adding BME or ENV. The solid line in each plot represents a perfectly normal distribution with the same mean value. The data points are difference values for each school. The closer the data points are to the line, the closer the data distribution is to a normal distribution. Overall, the data appears to follow a normal distribution in each case.

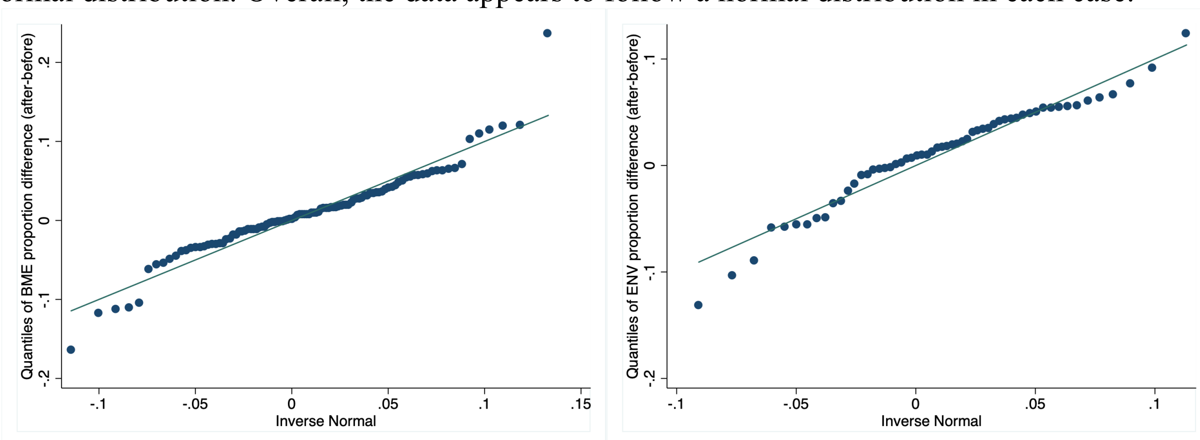


Figure 5: Q-Q plot for BME and ENV proportion difference (after-before) to determine normality.

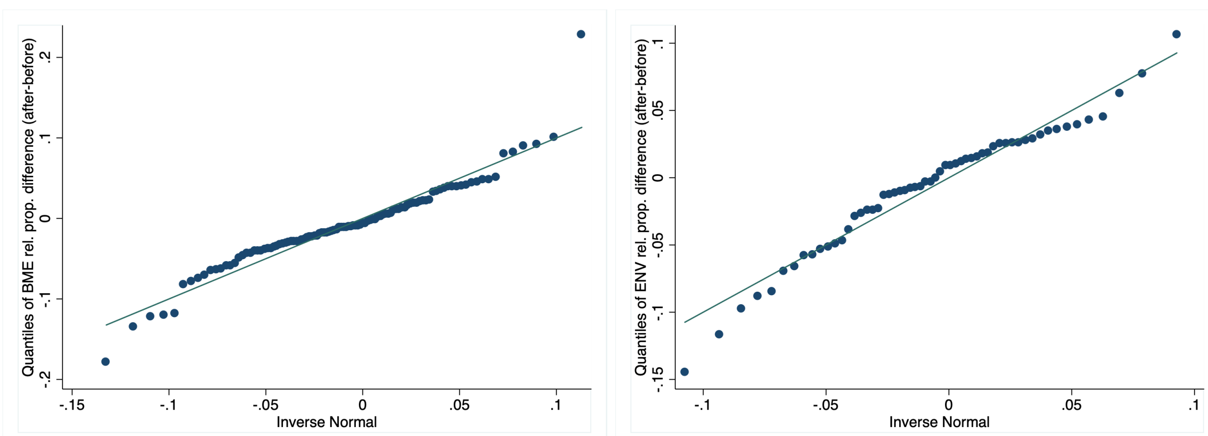


Figure 6: Q-Q plot for BME and ENV relative proportion (compared to US average in that year) difference (after-before) to determine normality.