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The role of female engineering faculty in female student success and belonging: A case study at California State University, Fresno

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The role of female engineering faculty in female student success and belonging: A case study at California State University, Fresno

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Abstract

Despite significant increases in female enrollment in engineering baccalaureate degree programs since the 1970s, the percentage of B.S. degrees awarded to female students in engineering continues to be the lowest of all fields in the United States. The problem is further compounded in minority serving institutions such as California State University, Fresno (Fresno State), for multiple reasons including lack of engineering role models and mentors for female minority students. In the currently ongoing study, the authors are investigating the relationship between the presence of female engineering faculty on female engineering student success metrics, e.g. graduation rates, confidence and sense of belonging among female engineering students. The hypothesis of this study is that increasing the number of female engineering faculty leads to increases in the student success metrics investigated for female engineering students. To test this hypothesis, a survey is being conducted on the female and male students of the Lyles College of Engineering as well as ten additional departments categorized as female-dominated and gender-balanced based on female student enrollment. In this article, the authors present the data on female engineering students in a quantitative historical context and are benchmarked against male engineering student as well as data from female-dominated and gender-balanced degree programs. The data analysis clearly shows that graduation rates of the female student are higher than the male students irrespective of the gender of the instructors. The survey questions for qualitative research on the perception of success for female students are also included.

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1. Introduction

Located in the San Joaquin Valley of central California, Fresno State is home to about 25,000 students. Being a state university, affordability is an important criterion for most students. The majority of the students in engineering come from local high schools and maintain close ties with the surrounding community. Recent reports published by the California State University Chancellor's Office [1] have identified engineering as one of the most impacted degree programs because of average graduation rates around 47%. To address this graduation challenge, the CSU system has launched various graduation initiatives. The initial analysis at the Fresno State campus has found that the six-year graduation rate of the female engineering students is 66.7%, in comparison with 45.2% for their male counterpart. Therefore, there has been some focus on further boosting the retention rates and recruiting more female students in engineering. More female faculty have been hired in the recent years to further support the female engineering students. However, the effect of female faculty on the success metrics of female students remains to be assessed. Therefore, this study has been undertaken to measure the various parameters contributing to the success of female students in the engineering field, which is known to have male dominance.

While women enrollment in engineering has seen consistent growth in the past seven decades, per the recent NSF report [2] the share of female students receiving engineering degrees has seen a decline since 2003. This has a serious implication on workforce diversity as the male-dominated engineering field might get increasingly more homogenous. It has raised concerns that female engineering students may be ill prepared to succeed [3]. The problem at underrepresented minority (URM) serving institutions e.g., California State University, Fresno (Fresno State), is further compounded by the fact that most female engineering students come from racial minority groups (mostly Hispanic background) and do not have engineering role-models either in their cultural environment nor at the academic environment. While racial diversity is important, and most universities are working to address that disparity, this study focuses on the gender disparity in engineering programs. Recruiting more female faculty to serve as a role-model has been argued to increase the success rate for female students by many researchers e.g.,[3], [4]. However, there are some seemingly contradictory findings as to when and where this role-model theory is applicable and what actually constitutes as success [5], [4].

Most of the published studies on female engineering students so far have been conducted by the researchers from psychology and gender studies background who may not have firsthand experience of prevailing culture in the engineering departments. The authors of this article are both female faculty in engineering and have firsthand experience of being a female student as well as female faculty in the field of engineering. The main focus of this article is to present the current trends and provide input for future policies in regard to female students and female faculty in engineering. In the following section, faculty and student demographics related to the sample populations investigated will be presented, followed by discussions of the methodologies to be used to assess quantitative and qualitative effects of female engineering faculty on female

engineering students. Comparisons will be drawn between the observed effects in engineering, a male-dominated field, and other gender-balanced STEM and non-STEM fields, as well as female-dominated fields.

2. Demographic Characteristics of Samples

The present study investigates the effect of female engineering faculty on the success and experience of female engineering students, focusing on Fresno State's Lyles College of Engineering (LCOE). As of Fall 2017, the LCOE had 1652 enrolled undergraduate students of whom 233 (14%) were female, which is well below the current estimates of National representation of women in undergraduate engineering programs of 22% [6]. Student distributions by gender, department, and student level (i.e. freshman through senior) are shown in Figure 1. Fresno State classifies student level based on the number of units a student has completed and may not necessarily reflect their progress in their degree program. Because many students take more units than that are required for a degree program, 'seniors' are disproportionately represented using this classification system. Because of the ethnic diversity surrounding Fresno State, the university serves multiple underrepresented minority populations and is officially designated as a Hispanic-Serving Institution (HSI) and an Asian American Native American Pacific Islander-Serving Institution (AANAPISI). Within the Lyles College of Engineering, 44% and 11% of its 1652 enrolled undergraduate students in Fall 2017 were Hispanic and Asian American/American Indian/Pacific Islander, respectively. A breakdown of the LCOE student population by gender and ethnicity is shown in Figure 2. During the same term, LCOE employed sixty-seven faculty, forty-two of whom were tenured or tenure track. These numbers include six tenured or tenure track female faculty and three female lecturers. LCOE faculty gender representation is summarized in Table 1. It is important to note that the percentage of female tenured or tenure track faculty is below the national discipline average for two of the three engineering departments [7]. While the representation of female faculty in civil engineering department is currently above the national average, this is a relatively new occurrence. Prior to Fall 2014, the department had zero female tenured/tenure track faculty. Noting both female faculty and female enrollment in engineering at Fresno State are trailing national averages, the authors wish to further explore the extent to which the female engineering faculty influence the female engineering enrollment.

Although not housed within the LCOE, computer science is closely associated with engineering and at many universities, is housed within a college of engineering. Similar to engineering disciplines, computer science is a male-dominated field. For these reasons, computer science was included in this study. To provide relative context to the analysis of the data from engineering and computer science, comparisons were made with ten other departments at Fresno State. Fall 2017 Enrollment and faculty data from each department considered in the study is tabulated in Table 2.

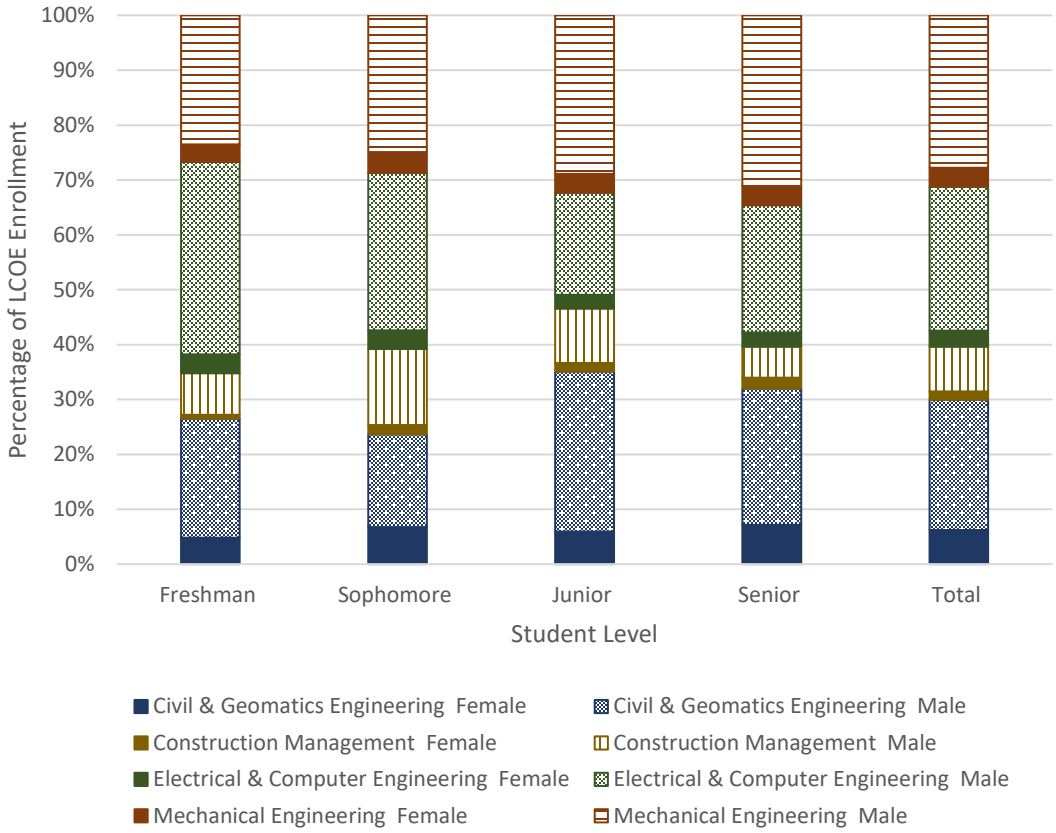

Figure 1. Distribution of undergraduate students in Lyles College of Engineering by gender, student level, and department.

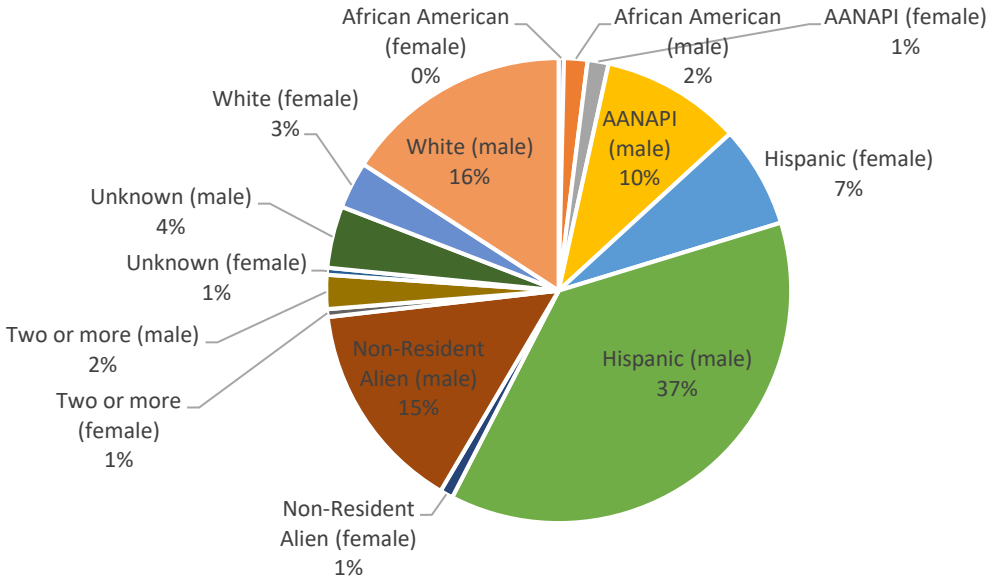

Figure 2. Fall 2017 Lyles College of Engineering undergraduate student demographics

Table 1. Fall 2017 summary of Lyles College of Engineering faculty demographics

Department	**Tenured/Tenure Track**		**Lecturers**		**% Female T/TT (CSUF)**	**% Female T/TT (National)**
	Female	**Male**	**Female**	**Male**		
Civil & Geomatics Engineering	4	11	1	9	26.7%	18.4%
Construction Management	1	3	1	3	25.0%	N/A
Electrical & Computer Engineering	1	11	0	5	8.3%	12.4%
Mechanical Engineering	0	11	1	5	0%	12.6%

Table 2. Fall 2017 enrollment data from Fresno State departments included in the study.

Department	**Enrollment**	**% Female**	**% Male**	**Number of Faculty**	**% Female**	**% Male**
College of Math & Science						
Biology	1027	64%	36%	24	50%	50%
Chemistry	345	54%	46%	31	45%	55%
Computer Science	367	15%	85%	11	9%	91%
Math	217	47%	53%	39	31%	69%
Craig School of Business						
Accounting	438	55%	45%	20	50%	50%
Management	408	50%	50%	30	37%	63%
Marketing & Logistics	251	44%	56%	14	36%	64%
Pre-Business	1620	43%	57%	NA[1]	NA	NA
College of Health and Human Services						
Communication Disorders	368	88%	12%	31	77%	23%
Nursing	1188	81%	19%	45	76%	24%
Public Health	588	77%	23%	28	43%	57%
Social Work	534	87%	13%	61	64%	36%
Lyles College of Engineering						
Civil & Geomatics Engineering	495	21%	79%	25	20%	80%
Construction Management	160	16%	84%	8	25%	75%
Electrical & Computer Engineering	481	10%	90%	17	6%	94%
Mechanical Engineering	516	11%	89%	17	6%	94%

[1]Students in the Craig School of Business are classified as Pre-Business until they meet the requirements to convert to their selected emphasis. All faculty are assigned to departments pertaining to the specific emphases.

Four departments from the College of Health and Human Services (CHHS), i.e. Nursing, Communication Disorders, Public Health, and Social Work, were selected because their gender ratios were similarly skewed to those of the engineering departments but with female students dominating the enrollment. While other departments on campus had similar female-dominated departments, e.g. Women's Studies, which is housed in the College of Social Sciences, departments within the CHHS were selected because 1) the college contained multiple departments with high female student representation, 2) the female student representation in these departments approximately matched that of the male student representation within the LCOE, 3) the overall college exhibited a female-dominant enrollment, i.e. 72.4%, and 4) for at least the last half century in the United States, health services baccalaureate degree programs have exhibited the highest female-concentration relative to other degree programs. Hence, the climate for male students wishing to pursue a career in health services is an ideal comparison to be made to female students in engineering.

For the purpose of this study, gender-balanced departments were defined as having female student enrollment between 33 % and 67 % (between one third and two third) of the total enrollment in that department. Six such departments were selected for this study with three from STEM fields housed in the College of Math and Science (CSM), i.e. Biology, Chemistry, and Math, and remaining three from non-STEM fields that are housed in the Craig School of Business (CSB), i.e. Accounting, Management, and Marketing. Pre-business is also included in Table 2 because at Fresno State, all CSB students begin as pre-business and switch to their preferred specialty once they meet the entrance requirements. Business departments were specifically chosen because in addition to the current female student representation at Fresno State being near 50%, Nationally, the percentage of business degrees awarded to women has increased dramatically over the last five decades. In 1970, less than 10% of business baccalaureate degrees were awarded to women, whereas today business baccalaureate degrees are awarded almost equally between men and women [8]. One of the driving motivations of this study is, therefore, to understand why business has had such success in equalizing its gender representation, while engineering and computer science have stagnated at under 20% female composition. The following section investigates historical correlations between the presence of female faculty and female enrollment and graduation rates in each of these departments.

3. Quantitative Objectives

Using data from the Fresno State Office of Institutional Effectiveness [7], the percentage of female faculty within each department will be correlated with the percentage of female student enrollment over the past twenty-seven years. While it is not possible to draw a conclusion regarding cause and effect from this data, the authors wish to understand the relationship between these two variables (female faculty and female students). Therefore, the important piece of information here is to find if an increase in female enrollment typically preceded by an increase in female faculty

or vice versa. Observing these trends for the business and science disciplines (fields which have seen increased female enrollment during this time frame) may provide insight into the conditions beneficial to increasing female representation in engineering disciplines. Data from Fresno State will be compared to national data from the National Center for Education Statistics [8]. Similar comparisons will be made between graduation rates and presence of the female faculty in various departments and majors.

The first two correlations are largely governed by the number of women choosing to enter the field, which is subject to a host of influences beyond the control of the faculty. A third correlation, which has fewer affecting factors, and therefore is perhaps the most likely to provide a meaningful correlation, is first year retention rates. While the engineering disciplines within the LCOE actually have higher retention rates for female students relative to male students, it is important to focus on continuing to improve these rates in order to increase the percentage of women attaining engineering degrees. Freshman cohort retention rates for each of the departments in the study will be compared relative to their female faculty representation. For departments within CHHS, each of the three correlations will be tracked for the male students, as their situation as the minority gender is similar to that of women in engineering.

The civil engineering department's hiring of four tenure track female faculty within a period of two years provides an opportunity to search for more direct evidence of the effect of female faculty on female students. These four faculty are from the fields of geotechnical and structural engineering, sub-fields within civil engineering that tend to be even more heavily male dominated than the general discipline. These faculty have taught many, if not all, of the foundational engineering mechanics courses (i.e., Statics and Mechanics of Materials), offered within the college. The authors wish to investigate whether the addition of these female faculty affected the percentage of the department's female students entering these sub-disciplines. The authors will use cohorts of students who attended prior to their hiring as a baseline. Additionally, the authors will compare the data from post-hiring cohorts based on whether they took a foundational engineering course with a female instructor.

While these correlations are of interest, the numerical information on retention and GPA only tells a part of the story. Considering the qualitative of experiences that women have in an engineering program in terms of classroom environment, interactions with peers, faculty, and staff may provide much deeper insight into the effect of female faculty in engineering. Thus a survey of students (male as well as female) from each of the departments in this study will be performed as discussed in the following section.

4. Survey to Assess Qualitative Effect

The retention and graduation data from the Fresno State's Office of Institutional Effectiveness [7] can be used to make quantitative assessments of the effect of female engineering faculty on female engineering students. However, assessment of more subtle effects of female engineering faculty on female engineering students, e.g., a student's sense of belonging in a major, comfort level etc., require surveying of students to solicit data regarding their feelings and perceptions. To this end, a survey was prepared and is being administered to students of all genders enrolled in undergraduate degree programs in the fifteen departments described previously. The survey begins by obtaining demographic information including major, gender, expected graduation year, grade point average, and the number of courses the student has taken within their college, e.g. The Lyles College of Engineering, and at Fresno State that have been taught by female faculty and the corresponding number taught by male faculty. The authors intend to explore hypotheses related to each of these attributes, are discussed below as they pertain to the rest of the survey questions.

The demographic questions are followed by asking whether the student intends, is considering, or does not intend to attend graduate school in their current field of study. It also inquires as to the gender of any faculty who have encouraged the student to attend graduate school. The responses from these two questions from female engineering students, along with the number of classes the student has taken with female faculty and the number of female faculty in the student's major (obtained from university data) will be analyzed to assess whether female faculty disproportionately affect a female student's propensity to pursue a graduate degree, relative to male faculty. Both direct effects (e.g. encouragement from faculty) and indirect effects (e.g. presence of faculty with advanced degrees acting as role models) will be considered. In performing this analysis, it will be relevant to control for proximity to graduation and GPA, as these are expected to affect a student's opinions regarding attending graduate school.

The survey continues by asking the respondent to indicate their level of agreement with five statements:

- I feel like I belong in my major.
- In the past, I have considered leaving my current major.
- I am currently considering leaving my current major.
- It is important to me to have professors within my major who are of my same gender.
- I prefer to have a mentor within my discipline who is of my same gender.

The first three statements serve as direct and indirect indicators of the level of belonging each gender has in their major. Once again, it will be important to control for GPA in this comparison as a student's level of academic performance is likely to affect whether they are or have considered changing major. The authors are particularly interested in comparing the perspectives of high

academically performing female and male students within engineering and other STEM disciplines to determine whether promising engineering and other STEM talent is being lost disproportionately by gender. The last two questions are aimed at determining the degree to which students desire to have same-gender professors and mentors. Respondents who indicate agreement with either of these statements will be prompted to select reasons for their answer. The responses from these two statements will be tabulated by gender and major with the number of same-gender faculty a student has had as a professor and the number of same-gender faculty within their major. The authors hypothesize minority groups, e.g. women in engineering or men in nursing, will place a higher significance on having same-gender faculty.

In the next portion of the survey, respondents are asked to indicate whether their gender is more, less, or equally suited for their field of study, whether their gender has more, less, or equal difficulty working in the industry related to their major, and whether an unfavorable, favorable, or no gender bias exists within their major

The second and third question solicit information regarding the respondent's perception of the gender-equity climate in their field of study, i.e. the manner in which gender-bias exists due to the beliefs and actions of others, whereas the first question attempts to directly gauge the gender bias of the respondent. Although more subliminal methods, e.g. the gender-career implicit association test (IAT) [9], are believed to provide a more accurate measure of the extent of gender bias (i.e. an individual may consciously select that all genders are equally suited for engineering, while a gender-career IAT may reveal an implicit bias against women; the latter is likely to be more indicative of their interactions with female engineering students and professionals), this direct approach is sufficient to provide a relative measure of overt sexism among the male dominated, gender-equal, and female dominated disciplines investigated. Furthermore, the authors are particularly interested in using this question to assess the extent to which students of a minority-gender consciously internalize the majority-gender to be better suited for their field.

The final portion of the survey asks whether the student has experienced gender related discrimination, harassment, or comments that have made them uncomfortable within their major. Respondents who indicate they have had these experiences are asked to indicate the gender of the faculty or other university employee (e.g. counselors or administrators) with whom they *first* discussed their experience provided they have discussed it with a university employee and how important the employee's gender was in their decision to approach them with the situation. If students indicated that they have not reported the incident(s), they are asked to indicate why and are provided with information regarding how to make such reports. The following are a list of hypotheses the authors wish to test with these questions:

- Harassment, discrimination and unwelcomed gender-related comments towards gender-minority students is negatively correlated with the minority gender's representation within their department faculty (e.g. these incidents are less frequent for female engineering students when a higher percentage of the department faculty are female).

- Gender-related harassment and discrimination is a more acute problem for female engineering students than it is for female students in gender-equal majors or male students male-dominated majors.
- Incidents of gender-related harassment and discrimination of female engineering students are more often reported to female faculty than male faculty.
- Fewer female engineering faculty is correlated with female students feeling less comfortable reporting gender-related harassment and discrimination.

5. Conclusions

Nationally, female enrollment in undergraduate engineering degree programs is increasin but is still trailing behind many other disciplines that were formerly male dominated. A similar trend is observed at Fresno State, but female engineering enrollment and female representation in tenured/tenure track engineering faculty remain below the national averages. The authors have set forth a methodology by which they propose to assess the quantitative effect of female faculty on female engineering student enrollment, retention, and graduation, which is informed by observations from gender-balanced and female-dominated departments at Fresno State. Furthermore, plans for a survey to assess the qualitative effect of female faculty on female engineering students were proposed. The results of these findings will be used to shape recommendations for policies on recruitment and retention of female engineering students.

6. References

[1] California State University, "Actionable Data for Faculty, Staff and Administrators (dataset)," (https://www2.calstate.edu/csu-system/why-the-csu-matters/graduation-initiative-2025/) accessed on Jan 2, 2018

[2] NSF, "Report on Science and Engineering Indicators," National Science Foundation 2016 (https://www.nsf.gov/statistics/2016/nsb20161/#/) Accessed on Jan 2, 2018

[3] E. P. Bettinger and B. T. Long, "Do faculty serve as role models? The impact of instructor gender on female students," *The American Economic Review,* vol. 95, no. 2, pp. 152-157, 2005.

[4] B. J. Drury, J. O. Siy, and S. Cheryan, "When do female role models benefit women? The importance of differentiating recruitment from retention in STEM," *Psychological Inquiry,* vol. 22, no. 4, pp. 265-269, 2011.

[5] S. Cheryan, J. O. Siy, M. Vichayapai, B. J. Drury, and S. Kim, "Do Female and Male Role Models Who Embody STEM Stereotypes Hinder Women's Anticipated Success in STEM?," *Social Psychological and Personality Science,* vol. 2, no. 6, pp. 656-664, 2011.

[6] B. L. Yoder, "Engineering by the Numbers," in *American Society for Engineering Education*, 2012.

[7] OIE, "Retention and graduation rates dataset," Fresno State Office of Institutiona . Effectiveness, (http://fresnostate.edu/academics/oie/data/) Accessed on Jan 2, 2018

[8] NCES, "National Center for Education Statistics (dataset)," (https://nces.ed.gov/programs/digest/d16/tables/dt16_325.45.asp) Accessed on Jan 2, 2018

[9] B. Nosek, M. Banaji, and A. Greenwald, "Project Implicit," (https://implicit.harvard.edu/implicit/) Accessed on Jan 2, 2018

7. List of Abbreviations

Fresno State: California State University, Fresno

CSU: California State University

OIE: Office of Institutional Effectiveness

LCOE: Lyles Collge of Engineering

CMS: College of Mathematics and Science

CSB: Craig School of Business

CHHS: Colllege of Health and Human Services

URM: Under-Representated Minority

HSI: Hispanic Serving Institutions

AANAPISI: Asian American Native American Pacific Islander-Serving Institution

NSF: National Science Foundation

NCES: National Center for Education Statistics

STEM: Science, Technology, Engineering and Mathematics

IAT: Implicit Association Test