Effects Of Numeric Representation Of Women On Interest In Engineering As A Career

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ABSTRACT

Little is known about how the presence of women influences undergraduates' experiences in engineering. This paper presents results from a mixed methods, multivariate, and multi-institutional study to determine the impact of the numeric representation of women on the intent to be employed in engineering following graduation. Results from the analysis of both quantitative and the qualitative data suggests that numbers matter because it contributes to the perception that women have the skills, abilities, and interests to succeed in engineering.

Keywords: Engineering; Gender; Persistence; Career Interests; Critical Mass

INTRODUCTION

The participation of women in engineering at the undergraduate level is a high visibility issue of national concern. Governmental and professional associations, such as the National Science Foundation (NSF) and the American Society for Engineering Education (ASEE), spotlight the issue as a national priority by tracking and reporting regularly on both the number and proportion of women completing degrees in engineering by institution. The proportional representation of women provides a ready point of comparison between institutions. Increases in the proportional enrollment of women have been used in research as a barometer of institutional effectiveness and success in making strides toward gender equity (e. g. Brainard, Kelly, & Wahl, 1993; Sonnert, Fox, & Adkins, 2007; Fox, Sonnert, & Nikiforova, 2009). What has not been made explicit in the national exchanges about this important issue is how the representation of women in engineering actually affects both men's and women's collegiate experience at the undergraduate level and what role it plays in longer term ambition to pursue engineering as a career option.

Across all institutions, women constitute 56 percent of the undergraduate population, but only 17.8% of the bachelor's degrees in engineering were awarded to women in 2008-2009 (Gibbons, 2009). The enrollment of women in engineering varies greatly by both type of institution and by discipline (Frehill, 2006). Growth in the enrollment of women largely has occurred in departments where there was a critical mass of women already (Frehill). In engineering at the undergraduate level, relatively high proportional enrollment of women and relatively high numeric enrollments are characteristics of two different types of institutions. High proportional enrollments of women in engineering can be deceiving as a metric because it is generally a characteristic of private institutions where overall numbers are relatively small. Higher numeric enrollment of women in engineering is associated with public institutions where overall numbers of students in engineering can be quite large. The "threshold effect" of critical mass is assumed to occur at about 15%, which is when there are sufficient numbers to impact the experiences of majority members (Etzkowitz, Kemelgori, & Uzzi, 2000). At a national level, some of the larger disciplines in engineering are close to or above the threshold for critical mass for women, including civil engineering (20.1%). A few are well above the threshold for critical mass, including biomedical engineering (35%) and environmental engineering where women account for more than 43.7% of the graduates (Gibbons, 2009). Although differences in the organization of disciplines make cross-institutional comparisons difficult (Frehill), it is logical to expect important differences in the educational environment of departments where women comprise 40% of the undergraduate enrollments, than in departments, like computer science and computer engineering, where fewer than 15% of the graduates are women.

Two frameworks are used to explain the under-representation of women in engineering and other fields in science and technology (SET) (Fox et al., 2009). One of these is an individual perspective that places the emphasis on individual differences in interest, abilities, and interests. The second is an environmental perspective. It shifts the spotlight to elements of the organizational context that influence the success and persistence of students in SET fields. The organizational framework sheds light on the pervasive influence of shared assumptions, beliefs, and values on practices in academic departments and the wider institution (Peterson & Spencer, 1991). These elements are mirrored in such things as the mission statement, admission requirements, course requirements, and underlying pedagogical assumptions about how students learn. An organizational framework would point to differences in the institutional culture in settings where, for example, lab assignments are designed primarily to advance mathematical ability and those designed to emphasize designing solutions to real-world problems.

This paper presents results from a mixed methods, multivariate, and multi-institutional study to determine the impact of the numeric representation of women on men's and women's intent to be employed in engineering following graduation. Numeric enrollment refers to a global measure of the number of graduates, as extracted from an institutional database made available through Internet resources supplied by ASEE. Quantitative data from student questionnaires (N=1629) were analyzed using multivariate analysis and hierarchical regression to determine the significance of the effects of number of women graduating in engineering on long-term interest in engineering. Long-term interest refers to the expectation of being employed in engineering in 10 years. Qualitative data collected from individual and group interviews with undergraduate engineering majors at participating institutions were used to explore the ways that students perceived that that representation of women in their field of student influenced their experiences. Results from the larger study are reported elsewhere (Creamer, Amelink, Meszaros, & Burger, 2009; *What's Good for Women, Is Good for Men Too*, 2010).

RELATED LITERATURE

The research literature about how the relative representation of women in a field is less than definitive about how it affects the experiences of undergraduates. The SET literature is silent about the ways that the representation of women affects men's experiences in engineering.

The theory of critical mass contends that there is a point at which the number of women on a particular environment brings about qualitative improvement in conditions and accelerates dynamics of change (Etzkowitz et al., 2000; Lagesen, 2007). The gender composition of a field affects perceptions of support for women, including the gender appropriateness of a field and about the likelihood of succeeding in that field (Sonnert et al., 2007). Performance is undermined where representation is low, producing patterns of both under- and over-achievement among women in reaction to the perception that others have low expectations for their success (Spangler, Gordon, & Pipkin, 1978). Low numbers restrict opportunities for social interaction and because students tend to form study groups with individuals who share their personal characteristics (Rosser, 1997), inhibit women's ability to participate in informal study groups and to form supportive networks.

The conceptual framework of critical mass also points to the positive effects of women in positions of structural authority, such as administrators and faculty members (Etkowitz et al., 2000). For example, the presence of senior females in the classroom improved overt male behavior toward women by reducing the amount of sexual joking and stereotyping (Etkowitz et al.). Female faculty members advise more women students and are more likely than their male colleagues to employ them in their laboratories (Sonnert et al., 2007). Women on the faculty play a key psychological role by providing role models, communicating that a field is "female friendly" (Etkowitz et al.), and signaling to women that an occupation is an appropriate choice for them (Sonnert et al.; Xie & Shauman, 2003). The presence of more than a token number of women on the faculty can offset some of the negative stereotypes about engineering, including that it is a field that is incompatible with outside interests and a social life that may be unwittingly perpetuated by amount of time out the classroom typically required to complete assignments in engineering.

Even proponents of critical mass as a viable theoretical perspective have observed that achieving what might be called the "tipping point" in critical mass, does not always improve conditions for women. Etkowitz et al. (2000) observed that critical mass can be a "false number" when women self-isolate or when segregated in subfields or in the micro cultures of laboratories. Similarly, they observed "It's also a false number if the departmental culture is so toxic that the freedom to associate with other women is subtly restricted" (p. 107). Steps to camouflage visibility, such as by distancing oneself from other women, are strategies that members of visible minorities often use to offset the tensions generated by under-representation (Kanter, 1977) or of poor climate. It can be taken to be an indicator of a positive climate when female students talk without hesitation about participating in female oriented clubs and activities, such as the Society of Women Engineers (SWE) or a women and science organization.

Etkowitz et al. (2000) concluded that in the final analysis, critical mass does not operate in entirely predictable ways. According to these authors, how women perceived that male peers treated them was more important than support offered by access to larger numbers of women. Particularly for women, peers play a central role in shaping views about the nature of work in engineering and about the match between personal skills and interests, and, consequently, long-term interest in it as a career (Creamer, 2011).

METHODS

In this mixed methods research project, the quantitative and qualitative data were linked sequentially. Following the analysis of the quantitative data and the development of the final regression equations reported in our 2009 report, we looked to the qualitative interview data to further understand key results. We used the quantitative and qualitative data to address two different research questions. The quantitative data answered the research question: Is there a significant impact of the numeric representation of women on men's and women's intent to be employed in engineering ten years following graduation? The qualitative data was used to answer the second question: How do students perceive that the representation of women impacts educational experiences?

Participating Engineering Colleges

The colleges/schools of engineering that were invited to participate in the study were selected to create a pool that was diverse in terms of the representation of women and other criteria that are relevant to the study, including overall size of enrollment in engineering, private and public control, and urban and rural location. Average proportional enrollment of women was based on the degree completion rates of women in all majors over a five-year period between 2003 and 2007 (*ASEE Profiles in Engineering and Engineering Technology Colleges, 2004, 2005, 2006, 2007, 2008*). Participating institutions are distributed throughout the Northeast, Midwest, and the West Coast. Proportional enrollment of women ranged from a low of 14% at one private and one public institution, to a high of 33% at a private institution. Total number of women completing an engineering degree at these institutions ranged from 41at a private institution with almost 2000 undergraduates in engineering to 212 at another private institution enrolling a total of 1700 undergraduate students. Institutions were not selected because they had initiatives and programs actively underway to promote the recruitment and retention of women in engineering. Table 1 displays information about the participating institutions. More information about the characteristics of the institutions participating in the study can be found in the 2009 publication, *Investigating the Gender Component: Cultures that Promote Equity in Undergraduate Engineering* (WEPAN Knowledge Center).

Table 1: Five-Year Average (2003-2007) of the Number and Percent of Female Graduates in Engineering among Participating Institutions

Category	Region	Carnegie Classification	Type	Average Number of Bachelor's Degrees In Engineering Awarded to Females	Average % of Bachelor's Degrees in Engineering Awarded to Females
High 1	Northeast	Research	Private	62	24%
High 2	Northeast	Research	Private	32	26%
High 3	Northeast	Research	Private	57	32%
High 4	Midwest	Research	Private	87	27%
Low 1	West	Research	Private	41	10%
Low 2	Midwest	Research	Public	54	16%
Low 3	West Coast	Masters	Public	74	16%
Low 4	Northeast	Masters	Private	44	14%
Low 5	Northwest	Research	Public	77	14%

*Data from *Profiles of Engineering and Engineering Technology Colleges* (American Society for Engineering Education, 2003-2008)

Data Collection Procedures

Members of the research team conducted campus visits to each of the nine institutions between 2006 and 2010. Seven of the nine institutions were able to coordinate the distribution of a questionnaire to all faculty and students in engineering prior to the campus visit.

Campus visits. Two or three person teams visited the campus of each of the participating colleges/schools of engineering for two days to meet with key administrators and to conduct individual and small group interviews with faculty and undergraduate students in two engineering departments having the largest number female students. Cash incentives were paid to students participating in interviews. Interview questions were designed to assess the qualities of students who do well in that educational environment and to learn about curricular and extracurricular activities that promote students', particularly women's, interest in engineering as a career.

The Engineering Student Survey. Members of the research team developed a student questionnaire incorporating sections and many of the key variables identified in *The Student Persisting in Engineering Survey* used in the Women's Experiences in College Engineering (WECE) Project (Goodman et al., 2002). *The Engineering Student Survey* differs from the questionnaire developed in the WECE Project by an overt gender focus and incorporating some constructs identified in previous research conducted by team members. The questionnaire contained 114 questions. After a set of demographic items, the questionnaire is organized in seven sections: (a) Important Factors in Career Choice, (b) Self-Assessment of Abilities, (c) Classroom Experiences, (d) Support Networks, (e) In- and Out-of-Class Engagement, (f) Opinions about University and Departmental Climate, and (g) Family and Educational Background. A Likert scale was used for the response options for most of the items.

Reliability of the instrument was established by conducting a Chronbach Alpha for the different sections. Results show that item groupings have from moderate (.40-.59) to strong reliability (.60 or higher), indicating that items grouped within a given section consistently measure the same concept. Content-related validity of the survey was established through review of questionnaire items for appropriateness of inclusion by a panel of individuals associated with the study.

Analysis

Data from questionnaires completed by students (N=1629) at the participating institutions were used to create a pool of individual and environmental variables with moderate to high reliability that had the most significant impact on students' short-term and long-term interest in engineering (Creamer, Meszaros, & Amelink, 2010). Short-term interest was measured by students' level of agreement to a single questionnaire item: "If I had to do it over again, I would still major in engineering"; long-term interest was measured by students' level of agreement with another questionnaire item: "It is likely I will be working in an engineering-related field ten years from now." A statistically significant gender differences was found on the second item, but not the first. 84.8% of the female and 92.4% of the male respondents indicated that they "definitely" or "probably" would be working in an engineering related field ten years from now. The remainder of the discussion focuses on the measure of long-term interest in engineering where the gender difference was significant.

A series of hierarchical multiple regressions were executed to determine if the numeric representation of women completing an undergraduate degree in engineering in all majors at the participating colleges where students completed questionnaires had any significant positive role in predicting long-term interest in engineering. Regression focuses on the prediction of one variable from other variables and is appropriate for both experimental and non-experimental research. The advantage of multiple regression is that it incorporates multiple independent variables and that both categorical and continuous variables can be used (Keith, 2006).

Separate regressions were run for men and women to better isolate the effects of the different individual and environmental variables. Variables were entered in three blocks, with variables measuring individual qualities entered first; variables measuring students' perceptions of elements of the undergraduate collegiate environment, second; and in the final step all variables simultaneously. In the final step of the analysis, it is possible to isolate the predictive power of a single variable and its statistical significance while controlling for multiple other variables simultaneously.

One of the advantages of multiple regression is that it focuses on effect size (Keith, 2006). Effect size is reflected in standardized beta weights (ß) and the R-squared. Beta weights range in size from minus to plus one. An effect size (R-squared) of more than .25 is considered strong (Keith).

When all the individual and environmental variables were added, both of the hierarchical regression equations described above produced strong R-squares. When using a sample weighted to reflect the enrollments in engineering at each participating institution, the variables considered had more predictive power for women (R-square=34%) than for men (R-square=21%). Detailed information about the relevant statistics for this procedure are presented elsewhere (Creamer & Amelink, 2010). Discussion presented in the results section address which of the variables remained significant in the final step of the analysis when all of the individual and environmental variables were considered simultaneously.

RESULTS

Results are presented in three sections. The first section summarizes the results from the hierarchical regressions conducted for men and women, considering the cumulative impact of a cluster of variables measuring individual qualities and a second cluster of variables measuring perceptions of elements of the educational environment. The environmental cluster includes the number of women completing a degree in engineering. The second section also deals with results from the quantitative analysis and considers variables in the model that might be expected to correlate in some systematic way to the numeric representation of women. The third section briefly refers to qualitative data for insight about students' perceptions about how the numeric representation of women influences their educational experience.

Graphing The Predictive Power of the Regression Equations

When three individual and four environmental variables were held constant in a hierarchical regression, the numeric representation of women among undergraduates engineering degree completers played no significant role in predicting the short-term measure of interest in engineering. In other words, it did not play a statistically significant role in the intent to remain in engineering voiced by undergraduates completing the questionnaire. Numeric representation of women did, however, persist at each step of the regression model as being a positive and statistically significant predictor for both men and women of the level of agreement with the questionnaire item about the long-term intent to be employed in engineering ten years from now.

In the final step of the hierarchical regressions, the average numeric representation of women among undergraduates completing degrees in engineering across five years played a small, but statistically significant role in predicting the measure of long-term interest in engineering. The role was positive for both men and women, but not surprisingly, the predictive power as measured by the standardized Beta weight (*B*) was more than twice as strong for women (.013, $p <= .000$) than for men (.005, $p <= .000$). The predictive power of a composite variable related to support from family and friends was much stronger, however. The effect of the numeric representation of women are unexpected in that they extend to men and, secondly, that the effect is not offset by individual factors, such as motivation and self-perceived ability, or environmental factors, such as climate or engagement in-and out-of-class. In other words, none of the variables considered in the quantitative analysis served to substantially reduce or mitigate the enduring, if small, over-all effects of numeric representation of women.

It is possible to graph the relationship between the dependent and independent variables produced by the regression equations by using the intercept (value at zero) and the slope (the increase in the dependent variable that is associated each unit increase in the independent variables). The slopes shown in the graph are the unstandardized regression coefficient multiplied by 100.

Figure 1 demonstrates how respondents' reported intent to be in an engineering related job in ten years (1=definitely not; 2=probably not; 3=don't know; 4=probably, 5=definitely) increased as the number of female engineering graduates grew from 30 to 80 in increments of 10.

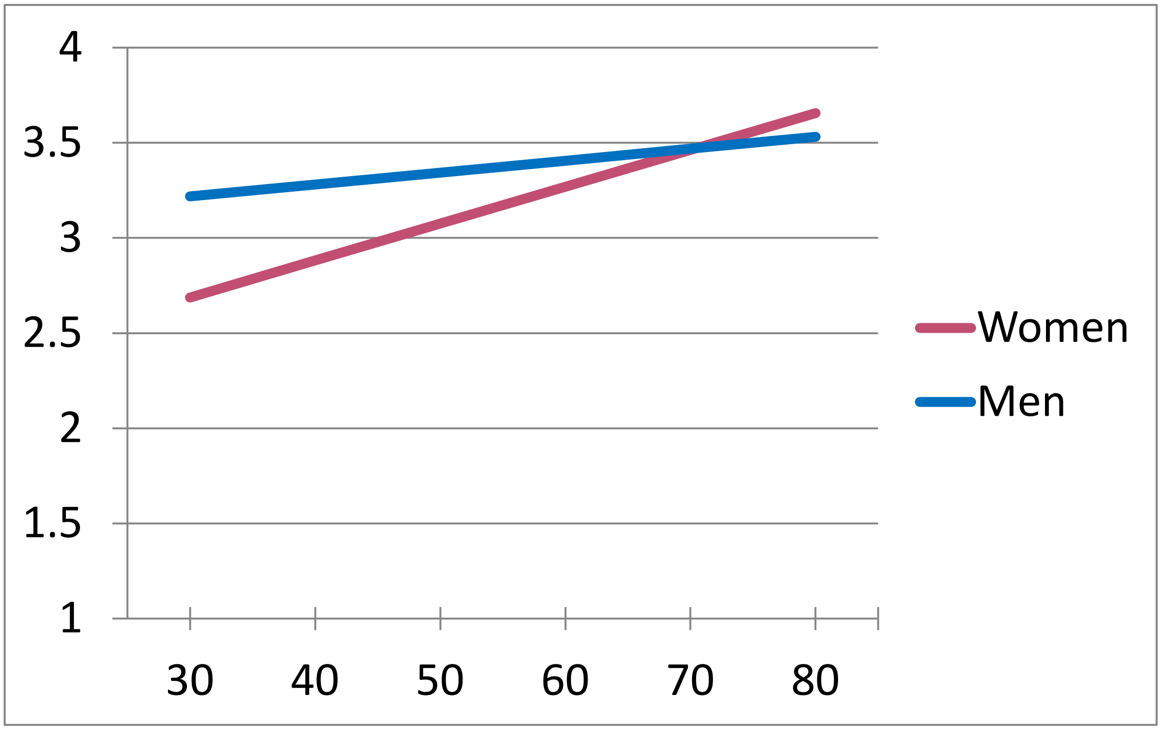

Figure 1: The Effect of the Number of Female Engineering Graduates Regressed on Women's and Men's Long-Term Interest in Engineering as a Career *

*Y axis shows level of agreement with the question; the X axis shows number of female graduates.

Figure 1 shows that for every increase of 10 women, women's interest in an engineering job following graduation increases .6% and men's interest increases .1%. The female and male regression lines are similar in that the lowest levels of interest are expressed by men and women in settings where there are fewer than 30 women in a graduating class. Women's interest grows steadily and in a positive direction the more women are present among graduates, while men's interest plateaus once there are 70 or more women in the graduating class. The flattening of the line projected for men in the graph suggests that there is a point of diminishing returns after which increases in the presence of women do not translate to increases in men's interest in an engineering job after graduation. The statistically significant, positive trends for both men and women shown in the graph persist after individual qualities, such as motivation, and environmental qualities, such as opportunities for engagement, are statistically controlled.

I now look to other statistical procedures to identify how the numeric representation of women in engineering influences perceptions of the educational environment.

Quantitative Explanations for How the Number of Women Affects the Educational Experience

Table 2 shows the correlations between the measure of the numeric representation of women in engineering and the cluster of individual variables and environmental variables considered in the hierarchical regressions for male and female respondents. A correlation coefficient is an index of the strength of a relationship between two variables without controlling for any other influences.

Of the 16 correlations coefficients shown in Table 2, only two are of sufficient strength to be statistically and practically meaningful and these were only for the female respondents. This is further indication that it is difficult to isolate what aspects of the educational experience are influenced by the presence of women in engineering, particularly for men.

Table 2: Correlations Between the Study Variables and the Numeric Representation of Women*

	Individual Variables			Environmental Variables				
	Ability	**Support**	**Motivation**	**Engagement**	**Climate**	**Respect/Care**	**Negative Factors**	**Prop. Rep.**
Female	N.S.	.395***	N.S.	-.267*	N.S.	-.106**	-.105**	N.S.
Male	-.034**	N.S.	.053***	-.081***	.066***	-.083**	-.058***	N.S.

*Weighted sample.

For women, there was a moderately strong relationship between the numeric representation of women among engineering graduates and two variables considered in the hierarchical regression: "Support" (r=.395***). and "Engagement" (r= -.267*). Like most of the other variables used in the study, Support was measured by responses to several questionnaire items related to fit. Questionnaire items in the Support variable are: "My parents think engineering is a good fit for me" and "My friends think engineering is a good fit for me" (1=strong disagree, 2=somewhat disagree, 3=somewhat agree, 4=strongly agree). The greater the number of women, the more likely the female respondents were to agree that parents and friends saw engineering as a good fit.

It is noteworthy that for women greater numbers of female graduates was negatively related to perceptions of Engagement, a factor that might be expected to increase for women in settings where the representation of women is greater. Responses to eight questions, all involving indicators of active engagement in- and out-of-the classroom measured engagement. For this group of questions, respondents were asked how often during the last term they engaged in academic activities such as serving as group leader in a project in an engineering class or meeting with a professor during office hours. It is likely that the significant negative relationship for women is confounded by the fact that larger enrollments of women are a feature of larger overall enrollments in engineering. Thus, the negative correlation coefficient indicates that for women, but not men, larger enrollments are associated with larger class sizes and fewer opportunities for engagement.

Insight from the Qualitative Data

The qualitative data from individual and group interviews with students during visits to nine different schools/colleges of engineering offered some insight about the effects of the numeric presence of women across all engineering majors on the educational experience for women. Some of the reasons offered by female participants are practical and short-term; while others are primarily psychological and longer term. Most of the explanations offered by participants pointed to social dynamics, including the ease of access to interact with like-minded peers, often through extracurricular activities. These all could be said to be conditions that reflect perceptions of support and affect a sense of fit. This refers to a global sense that others perceive women belong in engineering, but also to a narrower individual sense of belonging to a community.

When talking about the ways that the number of women in engineering affected their educational experience, participants pointed to very practical issues about the ability to make friends and to find study partners that simplified the logistics of completing homework and other assignments. The homework demands are intensive enough at most institutions that study partners are a particularly salient issue for students in engineering. Finding like minded friends also is a function of program size, as women in departments with larger female enrollments, such as biomedical engineering, have access to a larger pool of study partners than do women in a major like computer engineering where there are fewer women.

Two female participants at different institutions spoke to the importance of being able to make friends with people who, while not necessarily in the same discipline, have a sense of what it is like to be in engineering. From a public institution where women account for only about 15% of the more than 1800 students enrolled in engineering, one student commented freely about the importance of clubs as a way to meet and interact with other women. She said:

I am a member of the Engineering and Science Sorority … you and 30 girls who know exactly what you are going through. You've got a test or a project and they are like, "you know what, you don't have to come to whatever our thing is tonight, you've got a project, we all know how hard that is, go study." And that is great. You walk in a room, *you've had two tests, the professor yelled at the whole class because somebody did something with the homework assignment, and they are like "oh, I know, let's go have a cup of coffee and complain about our horrible engineering lives" which aren't horrible at all. It's just nice to have a sigma moment to commiserate with. Between the Society of Women Engineers and the sorority, I've been surrounded by female engineers all the way.*

Another female participant also pointed to the importance of extracurricular activities, while at the same clarifying that her choice to affiliate with other women had nothing to do with feeling excluded by men. From a selective private institution with a relatively high proportional enrollment of women of about 1500 students and over 40% of the students in her biomedical major, she noted:

I happen to become friends with three others girls that are in my classes, primarily because two of the girls were in an extracurricular group with me. So we became close with her roommate. We happen to be all female, but that is because we do activities outside of the classroom together. At no point did I feel like the guys didn't want to work with us or include us in a group.

The practical implications are less obvious with the psychological reasons identified for how the presence of women affects dynamics in engineering. These include the discomfort of being singled out, whether for positive or negative reasons, and informal messages that communicate it is possible for women to succeed in engineering.

A male and a female student in engineering at institutions with very different enrollment patters of women spoke in very similar ways about the discomfort of being singled out for unwanted attention and the message it carries of being different or not belonging. This may occur when there are only one or two girls in a class. A male student at a public institution with relatively large engineering enrollments observed:

I remember one of my classes in electronics. There were one or two girls in the class and it seemed like the professor singled them out a lot and asked them a lot of questions. I don't think if that was me I would want them to do that.

A female upper level student at a private institution with a relatively small overall enrollment of students in engineering, mirrored similar thoughts about being singled out when she said:

The only negative I have had was when I was in the electrical engineering classes and I was the only girl. I don't think it was anything about the school that made it that way, it is just awkward. I don't think it is much of a big deal; it just that it stands out.

One reason that the number of women on the faculty in engineering is a particularly important element of an institution's culture is because it provides a powerful message that the field is one where women can succeed without enduring consistently oppressive environmental conditions. An undergraduate woman at a private institution in the northeast with strong leadership and multiple initiatives to redress the imbalance in the gender ratio in engineering spoke to the value of women in prominent positions who serve as role models when she said:

…we have female faculty here. I do have role models who are the top people in their field who have been here for years. You can see them succeed. I never looked at it before coming here, saying okay I don't know the ratios, but I do know they go out of their way to try to find them, to bring them in. I know the ME department has quite a few females, and also IE and electrical engineering.

Participants voiced recognition of the imbalance in the gender ratio in engineering in one of two ways. While clearly aware of the disparity in a general way, most of the comments about the representation of women typically focused on experiences where the number of women was exceptionally small. With the exception of a few minority men, male students were unable to articulate ways that the presence or absence of women affected their experiences, except occasionally to voice some empathy with the discomfort of being singled by faculty out for extra attention. One would expect the relative absence of women in some fields in engineering to influence the attractiveness of it as a career and the potential to have a social life while pursuing it, but virtually no one in the study -- male or female -- articulated discomfort with the reality that engineering continues to be a male dominated profession.

DISCUSSION

Results from the analysis of both the questionnaire and the interview data support Sonnert et al.'s (2007) claim that the gender composition of a field affects perceptions of support for women, including its gender appropriateness and the likelihood of being able to do well. In other words, it communicates that women fit or belong in engineering. The quantitative data confirmed that that the numeric enrollment of women across all engineering disciplines in a school or college of engineering influences both men's and women's long-range plans. It had a small, but statistically significant positive effect on both men's and women's intent to be employed in engineering following graduation. This effect remained significant despite consideration of a range of individual and environmental variables that had the potential to offset it. As the number of women increased, both men and women were significantly more likely to say they expected to be employed in engineering following graduation. Interview data indicated that the numeric representation of women is important primarily because it communicates that women can succeed in the field, and, secondarily, because it affects social dynamics, including the ability of women to make friends and to find study partners to share the workload. When compared to disciplines outside of engineering, peer influence may be particularly strong in engineering because of the requirement for collaboration and the time demands are such that it requires the co-mingling of work and social life to accomplish.

Results support Ekowitz et al.'s (2006) conclusion that critical mass does not operate in a consistent way across settings. Conclusions drawn from the wider study that included interviews during visits to nine college campuses suggest that the benefits of comparatively good representation of women can be offset in an unusually toxic environment, just as a relatively low numeric representation of women can be offset by a positive climate. While growth in the number of women on the faculty and in the student body may over time serve to dilute a toxic environment, relatively strong numeric representation does not necessarily equate to an environment that is supportive of women any more than comparatively low numbers reflect an environment that is not supportive to women. The two campuses in our study where quantitative data pointed to serious concerns about support for women were both public institutions with relatively large undergraduate enrollments in engineering, including of women. Both of these settings were characterized by multiple years of exceptionally stringent fiscal restraints that limited hiring of a new generation of faculty members, and by an older generation of female faculty members who seemed genuinely uncomfortable talking about gender or associating with other women.

CONCLUSIONS

The project was conceived with an environmental perspective in mind, in that its aim was to identify what elements of the collegiate culture or climate have a significant impact on either short- or long-term interest in engineering as a major and as a career. The focus on the numeric representation of women, as measured by average number of graduates from all majors across a five-year span, reflects the study's emphasis on the environmental context. This perspective assumes that while there are important differences between fields in engineering, that there are also core ways of thinking and resolving problems, values, and beliefs that permeate across engineering disciplines. Clubs and extracurricular activities meant to support women in engineering that span fields, like the Society of Women Engineers (SWE), reflect the assumption that there are some underlying values and skills are common to the study and pursuit of engineering.

There are elements of a collegiate environment that affect an individual's perception that they belong in that field and their conviction that they can succeed in that field that have more to do with the institutional culture than with gender. For example, course requirements influence the amount and nature peer interactions through the amount of teamwork that is required and attitudes about competition. Access to like-minded peers is crucial in environments that place a premium on collaboration to complete homework and group assignments and where competition is not such that students feel pitted against each other for a small pool of good grades. A sense of fit is more readily produced in elite settings where selectivity is so high that there is a pervasive view that students' credentials to succeed in engineering are beyond question. A sense of fit is easier to promote in cultures where an emphasis is placed on the need for engineers to have a broad skill set so that everyone can find a place where their skills set is of value. It is less likely in settings where the disciplinary culture emphasizes a narrower skill set (e.g. math).

Future Research

The most unexpected result from the research was that the numeric representation of women played a significant role in predicting men's career interests and that these effects are long-term in the sense they have a significant effect on interest in pursuing a job in engineering following graduation. These effects remain significant even when motivation, support, and other environmental and individual variables are considered. While it is only possible to speculate about why greater numeric representation of women positively impacts men's long-term interest in being employed in engineering, the theme that has emerged about fit or support suggests that a more visible presence of women may ameliorate some of the negative stereotypes about the nature of work in engineering.

Even sophisticated statistical procedures did not fully explain why or how students' experiences are influenced by the presence of a critical mass of women. A study with a sample purposefully stratified to compare engineering disciplines with the most and least equitable gender ratios would make it possible to weigh how strongly perceptions about an educational environment are grounded in a collegiate and a departmental culture. It is possible that some of the widely available national databases may offer a more comprehensive way to explore the relationship between the numeric and proportional representation of women and persistence in engineering.

Best Practices

Elements of the culture in a college or school of engineering influence a student's perception that an environment is supportive of women, but it is too simplistic to assume that this perception is reducible to the presence or absence of a critical mass of women among the study body. When looking at the larger study, our attention is drawn to the values, beliefs, and practices in these settings that communicate that women belong in engineering not only because they have the skills and abilities to succeed, but also because these skills and abilities are needed to advance the discipline. Hallmarks of these settings include faculty members who communicate a pervasive belief that their students have the ability to be successful in engineering. A second element of these settings is dean-level endorsement about the importance diversity for the future viability of the profession and financial support for activities, including outreach activities that communicate this support. A third is extracurricular activities that promote informal interactions among students on topics that reflect contemporary views about the nature of engineering work in the 21^{st} century. A fourth characteristic is a gender and age-diversified faculty. A final characteristic is a curriculum that underscores the importance of real-world problem, collaboration, teamwork, and a diverse set of skills. All of these are elements of a collegiate culture that communicate that women belong and can succeed in engineering.

AUTHOR INFORMATION

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