the standing of *women* in academia

Surveys shed light on how well universities are utilizing the women engineers and scientists in the technical talent pool.

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In the midst of congressional hearings on applying Title IX to science and engineering, proposals to reduce visas to foreign engineers and scientists, and the U.S. Supreme Court considering the use of race as one factor in university admission policies, diversity is receiving increasingly more attention within the technical community. To help us better understand the diversity picture, it is instructive to review and analyze some of the available data. Here we examine the results of several recent surveys of women engineers and scientists in academia.

CHANGING CONCERNS AND STRATEGIES

During the last few decades, attention has been devoted to women in science and engineering — their status, distribution and prospects. Recently, there has been a focus on the challenges facing women in these fields and how to remove those barriers.

Challenges vary somewhat across technical disciplines, and even from one university to the next within a discipline. Differences arise because the disciplines are progressing toward diversification at different rates and, in some cases, along different paths. Because of this, an understanding of the status of women and the challenges they face in each discipline is crucial. Furthermore, with U.S. population demographics rapidly changing as the number of underrepresented minorities (URMs) — Hispanics, African Americans and Native Americans — increases, attention must also be given to the problems facing them in engineering and science.

FACULTY SURVEY RESULTS

We first studied the faculties of the "top 50" chemistry deparments, and characterized them by race/ethnicity, gender and rank (*AWIS [Association for Women in Science] Magazine,* **30** (2), pp. 10–16, Spring 2001). We then compared the representation of women and minorities among the tenured and tenure-track research chemistry and chemical engineering faculties (*AWIS Magazine,* **30** (3), pp. 33–39, Summer 2001, and *CEP,* **97** (9), p. 15, Sept. 2001). Chemical engineering was chosen for study second in order to probe a common perception about engineering — that the environment is harsher for women in engineering than in the physical sciences. Later, women wanted information about other science and engineering disciplines, so we expanded our studies further; more extensive data tables, including data for the social sciences, as well as new results as they become available, are posted at http://cheminfo.chem.ou.edu/faculty/djn/diversity/top50.html.

Table 1 summarizes FY2002 data for women faculty (regardless of race/ethnicity) in all engineering and science disciplines studied.

Women account for 10.5% of all tenured and tenure-track chemical engineering faculty — the highest percentage in the traditional engineering disciplines, and only slightly less than in computer science (which is considered an engineering, rather than a science, field). Women are fairly well-represented among chemical engineering faculties nationally at the lower ranks (21.4% of the assistant professors and 19.2% of the associate professors), but are not as prevalent among the full professors (4.4%). One explanation for the higher number of women at the lower ranks could be increased hiring recently, but another explanation could be that women chemical engineering faculty are experiencing a barrier to promotion.

Table 2 puts these data into perspective by comparing them with PhD attainment statistics and calculating "utilization rates" — *i.e.,* the percentage of women among faculty divided by the percentage of women among PhD recipients. The representation of women among chemical engineering assistant professors (21.4%) is in line with recent (1991–1999) female PhD attainment (20.2%). In all the traditional engineering disciplines, the percentage of women assistant and associate

Table 1. Female engineering and natural sciences faculty by rank (FY2002).

Discipline	Assistant Professor	Associate Professor	Professor	All Ranks
Chem Eng	21.4%	19.2%	4.4%	10.5%
Civil Eng	22.3%	11.5%	3.5%	9.8%
Electrical Eng	10.9%	9.8%	7.2%	6.5%
Mech Eng	15.7%	8.9%	3.2%	6.7%
Computer Sci	10.8%	14.4%	8.3%	10.6%
Chemistry, FY2001*	19.1%	20.1%	6.5%	10.7%
Chemistry, FY2003*	21.5%	20.5%	7.6%	12.1%
Physics	11.2%	9.8%	4.6%	6.6%
Math	19.6%	13.2%	4.6%	8.3%
Biological Sci	30.2%	24.9%	14.8%	20.2%

* Chemistry was surveyed in FY2001 and FY2003.

professors is greater than or very close to the percentage of women receiving PhDs during 1991–1999. (The only other discipline with such parity is sociology.)

An important use for this type of survey data is in deciding how to allocate limited resources. What are the biggest hurdles for women faculty? Some issues identified by our surveys are a lack of critical mass (when the percentage of women among faculty is less than about 15–30%) and an insufficient pipeline to ensure continued progress (measured by the percentage of women among PhD recipients), as well as the disparity between the two (utilization).

On average, the top 50 chemical engineering departments have not achieved a critical mass of female professors (10.5%, Table 2, column E). This number is undesirably low, but chemical engineering is doing better than the other engineering disciplines (except for computer science, which is at 10.6%). Even more interesting, chemical engineering almost matches chemistry (10.7%), even though PhD attainment by women in chemical engineering (20.1%) has been only about two-thirds that of chemistry (29.5%) since 1991. When only U.S. natives receiving their PhDs during 1991–1999 (Table 2, column G) are considered, representation of women among chemical engineering faculty (16.5%) surpasses that of chemistry (15.6%). As expected, the representation of women on chemical engineering faculties is lower than that in the social sciences, because in those disciplines the pipeline of women PhDs is much larger.

URMS AMONG ENGINEERING AND SCIENCE FACULTY

We were surprised that our initial surveys found no African American assistant professors in chemistry or in chemical engineering, but different reasons were responsible for this apparent similarity in the two disciplines. In chemistry, no African American assistant professors had been hired into the top 50 departments since 1991. In chemical engineering, African American assistant professors had been recently hired, but had already been promoted to associate professor. The FY2003 chemistry survey update identified two African American assistant professors — one male and one female.

URM women are particularly underrepresented on the top 50 faculties. In the eight "hard sciences" combined (the five engineering and three physical science disciplines), there are 49 female URM faculty — 17 African American, 31 Hispanic and one Native American. There are only ten full professors (all Hispanic) among these, of which only five are U.S. natives. Thus, female URMs in these disciplines represent less than 0.5% of the faculty, but over 1.5% of the PhDs.

Chemical engineering has five female URM professors — two African American (both are associate professors and are U.S. natives) and three Hispanic (all are assistant professors and two are U.S. natives). Table 3 summarizes the demographics of the faculty at the top 50 chemical engineering departments.

UTILIZATION OF WOMEN

Because the representation of women among faculty is influenced by the number of women in the pipeline, we calculated utilization rates to study the degree to which the two match in each discipline. This is an indication of how women PhDs are being placed and retained in faculty positions. If women in the pipeline are fully utilized, utilization will be 1.00; a number less than 1.00 indicates that women are underutilized.

The initial goal of generating utilization numbers to com-

Table 2. Representation of women among all PhD recipients and among FY2002 faculty, and utilization rate (%faculty/%PhDs).

Discipline	A % Women PhDs 1983–1999	B % Women PhDs 1991–1999	C % Women Faculty — Assistant	D % Women Faculty — Asst & Assoc	E % Women Faculty — All Ranks	F Utilization† All Ranks (E/A)
Chem Eng	17.2	20.2	21.4	20.2	10.5	0.61
Civil Eng	14.2	16.5	22.3	16.2	9.8	0.69
Electrical Eng	9.0	10.5	10.9	10.2	6.5	0.72
Mech Eng	8.2	9.6	15.7	11.5	6.7	0.82
Computer Sci	19.3	20.1	10.8	12.6	10.6	0.55
Chemistry. FY2001*	25.9	29.5	19.1	19.5	10.7	0.41
Chemistry, FY2003*	25.9	29.5	21.5	21.1	12.1	0.47
Physics	11.0	12.8	11.2	10.3	6.6	0.60
Math	23.5	25.7	19.6	16.0	8.3	0.35
Biological Sci	40.0	43.1	30.2	27.5	20.2	0.51

Discipline	B % Women PhDs 1991–1999	G U.S. Women with PhDs 1991–1999	H Utilization U.S. Women (G/B)
Chem Eng	20.2	16.5	0.82
Chemistry, FY2001*	29.5	15.6	0.53
Chemistry, FY2003*	29.5	16.4	0.56

* Chemistry was surveyed in FY2001 and FY2003.

† Utilization rates for assistant professor and associate professor ranks are based on 1991–1999 data, whereas utilization rates for all ranks combined are based on 1983–1999 data since full professors are more likely to have received their PhDs earlier.

Note: More extensive data, including utilization calculated by other means, can be found athttp://cheminfo.chem.ou.edu/faculty/djn/diversity/top50.html.

pare across disciplines was to help women scientists and engineers understand that they are not all in the same situation and should not expect their perceptions about the environment for women to agree. A valuable product of our studies was, therefore, a set of utilization numbers based on national data that are comparable across disciplines. Utilization, combined with critical mass and pipeline data, can reveal the types of problems faced by women in a particular discipline.

For example, a female chemical engineering professor might perceive an insufficient PhD pipeline (17.2% female) and no critical mass of women (10.5%), but think that universities do a fairly good job of placing women PhDs in faculty positions (utilizations of 0.61 to 1.06). However, a female biology professor might see exactly the opposite — a pipeline composed of 40% women and faculties consisting of 20.2% women, yet utilizations ranging from 0.56 to 0.70. They would both be correct. Sometimes women disagree when discussing the status of women because their perspectives have been shaped by their own experiences within different disciplines, which provide different environments. The data in Table 2 (columns A, E and F) demonstrate that this is to be expected.

Patterns in utilization, critical mass and pipeline data are illustrated in Table 2. For example, these parameters are similar across the engineering disciplines, but different than those for the natural sciences. Thus, the experiences of women chemical engineering faculty will more likely be similar to those of women in mechanical engineering than to those in chemistry. Identifying and grouping disciplines with similar problems will facilitate the formulation of plans for addressing women's issues within and among these groups.

Regardless of how utilization is calculated (see sidebar), we found that although the numbers vary slightly, the ordering of the disciplines is approximately the same: engineering > social sciences > life sciences ~ physical sciences. Therefore, I recommend using utilization ordering to compare disciplines rather than using the absolute numbers to analyze one particular discipline.

Utilization data for other race/ethic groups indicate that Caucasian men are overutilized in every discipline, with utilization rates ranging from 1.02 in mechanical engineering to 1.40 in biological sciences (1.15 in chemical engineering). URMs are generally underutilized (utilization < 1, from 0.45 in computer science to 0.99 in chemical engineering). In chemical engineering, the utilization of women and URMs is closer to 1, indicating that their representation on faculties is closer to their representation among PhD recipients. This is true for most of the other engineering disciplines as well.

OVERALL PERSPECTIVE

The data in Table 2 reveal a rather large variation in critical mass attainment, pipeline and utilization of women across the engineering disciplines. Some disciplines have critical mass, some don't; some have reasonable pipelines, some don't; some disciplines have a fair women-faculty-to-PhD-attainment match, some don't. It is important for women in different fields to understand that it may be normal for them not to perceive the same environments. Finally, because this was a national study, these results will not describe any university in particular, but in the absence of other data, the relationships presented here could be used to formulate initial plans for improving engineering and science departments.

Sometimes it is said that progress for women in the physical sciences seems to be on the same path as in the social sciences and life sciences, except it is about 20 years behind. That analysis fits our data. Progress in those disciplines was and still is being made by first increasing the pipeline of women, which later causes a corresponding, but smaller, increase in women faculty. This means that the problems faced and solutions found in the social sciences and life sciences years ago might be a source of ideas for dealing with problems facing women and minorities in the physical sciences today.

However, progress for women in engineering seems to be on a different path. The representation of women on engineering faculties (except possibly computer science) seems to be much closer to that of PhD attainment, without such a long time lag.

CONCLUSIONS

So, the perception that chemical engineering has an environment that is worse for women than chemistry seems to be unfounded. PhD attainment by women chemical engineers is indeed lower, but the representation of women on the faculties and their utilization is equal or better. This means that chemical engineering is doing a better job of placing its female PhDs than chemistry is.

I have heard different explanations for this. One reason posed by engineering department chairs was that since engineering research is applied, engineers must focus on societal needs; therefore, they are more aware of diversity is-

Survey method

The numbers of tenured and tenure-track faculty, broken down by race/ethnicity, by gender and by rank, were solicited from the chairs of the "top 50" (as identified by the National Science Foundation) engineering and science (natural and social sciences) departments in the U.S. Throughout all the surveys, when a question arose as to how to interpret data or to categorize a person, the issue was resolved in a manner that understated the underrepresentation — *i.e.,* that increased the number of females for gender studies, minorities for race/ethnicity studies, and natives for national origin studies.

To avoid bias, any chairs' comments that were returned with the surveys were initially ignored. Later, however, we realized that the comments reinforced the data. It was difficult to ignore the disparity between a typical comment from a chemical engineering chair (*e.g.,* "Thank you for doing this extremely important survey.") versus one from a physical science chair (*e.g.,* "I think this is a waste of time, but I guess I'll give you the data."). Moreover, all 250 engineering department chairs provided data for the surveys, while at least one chair in every other discipline declined to participate. These were our first indications that a common perception about engineering — that the environment is harsher for women in engineering than in the sciences — might be wrong.

Table 3. Demographics of chemical engineering faculties at the Top 50 U.S. engineering schools (FY2002).

	Number	Percent	
Caucasian			
Male	606	73.9%	
Female	72	8.8%	
Total	678	82.7%	
Asian			
Male	93	11.3%	
Female	9	1.1%	
Total	102	12.4%	
Hispanic			
Male	24	2.9%	
Female	3	0.4%	
Total	27	3.3%	
African American			
Male	11	1.3%	
Female	2	0.2%	
Total	13	1.6%	
Native American			
Male	0	0%	
Female	0	0%	
Total	0	0%	
Total*			
Male	734	89.5%	
Female	86	10.5%	
Total	al	820	100.0%

* Excluding degree recipients who did not indicate race

sues. Another more common response has been simply "We are engineers; engineers solve problems."

Whatever the reason, engineering does seem to have incorporated and retained women and minority PhDs into their faculties in proportions more closely matching those of PhD attainment than the physical science disciplines have. It might be beneficial to determine which engineering department practices and programs have led to higher utilization of women and URMs, and use those as models for the other disciplines.

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Methods of calculating utilization

The selection of numbers used to calculate utilization has been of great interest. Based on input from dozens of female scientists, minority professors and American Chemical Society (ACS) officials, one method was judged acceptable at providing national-level utilization numbers that are meaningful and obtainable with a reasonable amount of effort.

Initially, it seemed best not to compare the percentage of women faculty (Table 2, column E) vs. the percentage of women among PhD recipients (column A), because the resulting utilization numbers (column F = E/A) included faculty who had received their PhDs prior to 1983 and they would be predominantly male. It was suggested that we compare the percentage of women in the junior faculty ranks (column D) vs. the percentage of women among recent PhD recipients (column B), but these utilization rates were inflated because women were much more likely to get stuck at the associate professor level than men were. It appeared that the best utilization calculation would compare the percentage of women assistant professors (column C) vs. the percentage of women among recent PhDs (column B), but inflation due to foreign female faculty became an issue. It seemed that no comparison would be acceptable to all parties because national origin data were unavailable.

To supplement the data submitted by the chemistry department chairs, we gathered additional data on individuals' national origin from websites and the "ACS Directory of Graduate Research." For each faculty member, we also included BS year and school and PhD year and school. Then, we labeled faculty receiving their BS in the U.S. as natives and compared the percentage of native female professors receiving their PhD during 1991–1999 (column G) vs. the percentage of women among PhD recipients during 1991–1999 (column B). This utilization calculation (column H) was universally accepted. However, we know that it is actually slightly inflated, because some female professors included in the survey responses were (we discovered upon further investigation) not tenure-track. To compare chemistry with chemical engineering utilization, we similarly gathered native origin data for chemical engineering faculty.

While acceptable, this totally rigorous utilization calculation (which we performed three times, for chemical engineering in FY2002 and chemistry in FY2001 and FY2003) required cataloging of information that was very tedious to obtain — so tedious as to make the technique impractical. Moreover, obtaining native origin data for disciplines other than chemistry and chemical engineering would be even harder, because those don't have a resource similar to the "ACS Directory of Graduate Research."

The approximation method yielding utilization numbers (column F) closest to those of the rigorous calculation was that comparing the percentage of women faculty in all ranks (column E) vs. the percentage of women receiving PhDs during 1983–1999 (column A). The fact that these values are slightly lower than those produced by the rigorous calculation is not a cause for concern, because we know the rigorous method is slightly inflated (as discussed above). In particular, the data for chemistry and chemical engineering were most similar between the rigorous method (column H) and the approximation method (column F).

Thus, when dealing with smaller groups of subjects, the totally rigorous method (column H) would be best. However, when dealing with thousands of subjects for whom it is not practical to gather all the required data, the approximation method using the percentage of women among all faculty and the percentage of women among PhD recipients during 1983–1999 (column F) gives adequate information for making comparisons among disciplines.