

# **Attracting and Retaining Women in Engineering: The Tufts Experience**

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**Cornell Higher Education Research Institute Policy Research Conference**  
*Doctoral Education and the Faculty of the Future*  
**Ithaca, NY -- October 8-9, 2006**

**ABSTRACT:** Engineering in the United States is a field that has been, and continues to be, predominantly male. This poses problems relating to: creation and maintenance of an adequate scientific and technical labor force; fostering diversity in approaches and perspectives for solving engineering problems; and basic equity. The School of Engineering at Tufts University in Massachusetts has a significantly larger percentage of women among both its students and its faculty than the national averages. This article is a case study of aspects of the School of Engineering at Tufts that may help to explain why the school has been more successful in recruiting and retaining women at all levels. Topics covered include the integration of schools; administrative leadership; targeted student recruiting and support programs; features of the curriculum and extra-curricular programs that may play a role in recruitment and retention of female students; careful monitoring of faculty hiring; and structural supports for faculty, particularly junior faculty.

## **(I) Introduction and data**

In the United States, Engineering is an academic field that has been, and continues to be, predominantly male. In recent years, only about one in five degree recipients has been female. This has an obvious impact not only on the composition of the academic labor force and of our Engineering classrooms, but also on the composition of the Engineering labor force beyond the walls of academia. The basic data for female engineering students and faculty are summarized in Tables 1 and 2.

Low representation of women is not necessarily a problem, unless one believes that:

1. The United States is facing a crisis in the creation and maintenance of its scientific and technical labor force, and is no longer training enough people to fill current and anticipated demand. If one is concerned about the competitive position of the United

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**TABLE 1: WOMEN RECEIVING ENGINEERING DEGREES AS A PERCENT OF ALL ENGINEERING DEGREES,  
TUFTS UNIVERSITY AND ALL ENGINEERING SCHOOLS IN THE U.S., 1998-2005**  
(total number of degrees in parentheses)

|                                | <u>1998</u>     | <u>1999</u>     | <u>2000</u>     | <u>2001</u>     | <u>2002</u>     | <u>2003</u>     | <u>2004</u>     | <u>2005</u>     |
|--------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>TUFTS UNIVERSITY</b>        |                 |                 |                 |                 |                 |                 |                 |                 |
| Bachelors Degrees              | 28.4 (162)      | 39.7 (237)      | 27.0 (159)      | 23.2 (194)      | 30.1 (193)      | 33.3 (195)      | n.a             | 26.8 (164)      |
| Masters Degrees                | 45.8 (70)       | 31.1 (106)      | 39.0 (105)      | 45.1 (91)       | 31.7 (120)      | 31.7 (123)      | 32.5 (160)      | 21.9 (155)      |
| Doctoral Degrees               | 31.6 (19)       | 22.2 (9)        | 50.0 (12)       | 50.0 (10)       | 63.6 (11)       | 25.0 (8)        | 55.6 (9)        | 50.0 (8)        |
| <b>ALL ENGINEERING SCHOOLS</b> |                 |                 |                 |                 |                 |                 |                 |                 |
| Bachelors Degrees              | 19.1<br>(58255) | 21.5<br>(61645) | 20.9<br>(64008) | 20.1<br>(64567) | 20.9<br>(66869) | 20.4<br>(71525) | 18.2<br>(73028) | 19.5<br>(73428) |
| Masters Degrees                | 20.5<br>(25822) | 24.0<br>(28875) | 21.8<br>(29929) | 22.1<br>(30706) | 22.2<br>(31097) | 22.3<br>(35196) | 21.9<br>(39814) | 22.7(40626)     |
| Doctoral Degrees               | 12.6<br>(6150)  | 17.3<br>(5916)  | 15.9<br>(5989)  | 17.0<br>(6058)  | 17.3<br>(5774)  | 17.4<br>(5870)  | 17.8<br>(6603)  | 18.3 (7319)     |

Source: ASEE Engineering Data  
<http://www.asee.org/datamining/reports>

**TABLE 2 – Percentage of Faculty in Engineering Who are Women**

| <b>TABLE 2: Percentage of Faculty in Engineering Who are Women</b> |                                                |              |              |                                             |                  |                   |
|--------------------------------------------------------------------|------------------------------------------------|--------------|--------------|---------------------------------------------|------------------|-------------------|
|                                                                    | Top 50 Departments in<br>Selected Disciplines* |              |              | School of Engineering<br>Tufts University** |                  |                   |
|                                                                    | Asst<br>Prof                                   | Asso<br>Prof | Full<br>Prof | Asst<br>Prof                                | Asso<br>Prof     | Full<br>Prof      |
| ENGINEERING                                                        | 16.94                                          | 11.17        | 3.68         | 50.0<br>(4 of 8)                            | 6.3<br>(1 of 16) | 8.0<br>(2 of 25)  |
| Biomedical                                                         | n.a.                                           | n.a.         | n.a.         | 100.0<br>(1 of 1)                           | 0<br>(0 of 3)    | 0<br>(0 of 2)     |
| Chemical                                                           | 21.38                                          | 19.19        | 4.37         | 0<br>(0 of 2)                               | 0<br>(0 of 2)    | 25.0<br>(1 of 4)  |
| Civil                                                              | 22.26                                          | 11.50        | 3.52         | 100.0<br>(1 of 1)                           | 0<br>(0 of 6)    | 14.3<br>(1 of 7)  |
| Electrical                                                         | 10.86                                          | 9.84         | 3.85         | 50.0<br>(1 of 2)                            | 33.3<br>(1 of 3) | 0<br>(0 of 4)     |
| Mechanical                                                         | 15.65                                          | 8.89         | 3.17         | 50.0<br>(1 of 2)                            | 0<br>(0 of 2)    | 0<br>(0 of 8)     |
| COMPUTER<br>SCIENCE                                                | 10.82                                          | 14.41        | 8.33         | 0<br>(0 of 3)                               | 42.9<br>(3 of 7) | 100.0<br>(3 of 3) |

\*Data on faculty come from the same “Top 50” departments for each discipline; departments are ranked by NSF according to research expenditures in that discipline. Faculty data are from 2002.

\*\* Data on SOE, Tufts University faculty come from the *Faculty Retention Cohort Study*. Data are from October 2005.

(REF: Handelsman, et.al. *Science*. Vol. 309, pp. 1190-1191. August 19, 2005; and *Faculty Retention Cohort Study*. Tufts University AS&E Office of Diversity Education and Development. February 2006.)

States, Engineering needs women. “Now, more than ever, the nation needs to cultivate the scientific and technical talents of all its citizens, not just those from groups that have traditionally worked in SET [Science, Engineering, and Technology] fields. Women, minorities, and persons with disabilities currently constitute more than two-thirds of the U.S. workforce. It is apparent that just when the U.S. economy requires more SET workers, the largest pool of potential workers continues to be isolated from SET careers.” (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. *Land*

*of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology.* September 2000.)

2. The relative absence of women from Engineering robs the field of the potential for additional perspectives on a wide range of problem-solving issues, from how to approach a research project to how to manage a group of people, in the classroom, the office, or the field. If one is concerned about quality, Engineering needs women. Some argue that simply drawing upon all people, regardless of sex, would mean that science and engineering would thereby tap the largest pool of qualified people, and would end up with the most qualified possible workforce. Others argue that women as a group bring distinctive perspectives, and even ways of thinking, that would add beneficial diversity and innovation to the very ways in which science and engineering are done. (For discussions of these issues, see Yu Xie and Kimberlee A. Shauman. *Women in Science: Career Processes and Outcomes.* Cambridge, Massachusetts and London, England: Harvard University Press, 2003; and Londa Schiebinger. *Has Feminism Changed Science?* Cambridge, Massachusetts and London, England: Harvard University Press, 1999.)

3. Women and men should have equal access to the complete range of jobs in a society, including the well-paid, interesting ones. Whether the barriers to women in Engineering are outright discriminatory practices (vanished by now, one would hope, with only their legacy to contend with); structural constraints (e.g., an employer's lack of maternity leave, which has the [perhaps unintended] consequence of affecting women more than men); or informal cultural norms, behaviors, and attitudes that have the effect of excluding women (e.g., a professor who only calls on male students in class), it is important to address them so that the playing field becomes truly level. If one is concerned about equity, Engineering needs women.

Tables 1 and 2 also present data from Tufts University School of Engineering (SOE), located in the near suburbs of Boston, Massachusetts. These data on women in Engineering appear to deviate substantially from the national averages.

#### *Student Recruitment, Retention and Achievement*

While in 2005 women earned 19.5% of the Bachelor's degrees at all Engineering schools in the United States, at Tufts women earned 26.8% of the Engineering Bachelor's degrees. Not only are female undergraduates recruited and retained at the SOE, they also do well academically, on average better than their male counterparts. Combining the five graduating classes of 2001 through 2005, females made up 29.1% of a total of 973 graduates. The average GPA for females was 3.30, higher than the average GPA for males (3.24).

### *Faculty Retention*

In addition to a strong record of female undergraduate enrollment and academic achievement, the SOE at Tufts also has a strong record of faculty retention. Of all tenure-track faculty hired in the SOE from AY90-91 through AY04-05, 40.5% (17 out of 42) were women. To assess retention, we selected the cohort years from AY90-91 through AY98-99. All faculty hired within that period have been at Tufts long enough for their tenure review to have been resolved. Of the 19 faculty hired during those nine years, we have retained 50% (4 out of 8) of the women, and 64% (7 out of 11) of the men. And we have high hopes for the future. Of the 23 faculty hired from AY99-00 through AY04-05, nine were women. Three of these women have already received tenure, and the rest are still with us at Tufts. (Fourteen men were hired during this same period. Twelve are still at Tufts, of whom three have already received tenure.) (*Faculty Retention Cohort Study*. AS&E Office of Diversity Education and Development. February 2006.)

### *Administrative Appointments*

In 2003, Professor Linda M. Abriola, previously of the University of Michigan, was appointed the Dean of the School of Engineering at Tufts. A member of the National Academy of Engineering and of the American Academy of Arts and Sciences, Dean Abriola is an expert on groundwater contamination and remediation. When she was appointed, Dean Abriola was one of a very small number of female Engineering deans at Division I research institutions. At the SOE, the Dean convenes an Engineering Cabinet, which includes the top administrators assigned to various functional roles throughout the School. As of September 2006, the Engineering Cabinet is 40% female (4 out of 10).

Tufts is not the only Engineering school that has a better-than-average record of employing and educating women. For example, the statistics show that the percentage of women graduating with Bachelors degrees in 2005 from a number of other institutions were impressive as well: Caltech (33% of 96); MIT (35% of 593), Morgan State University (37% of 79), Brown (35% of 66); University of Pennsylvania (30% of 349); Princeton (36% of 181); Yale (41% of 54); and University of California, Berkeley (28% of 776). (ASEE statistics, 2006, data mining tool.)

Although we still have a lot left to do to improve our recruitment and retention of women in the SOE at Tufts, we are proud of our achievements to date and to be among the handful of institutions that are exceeding the averages. How have we accomplished this? What follows in this presentation [article] is a case study of Tufts and what we have done so far to increase the number of women in Engineering.

## **(II) The Tufts context: Fertile ground for recruiting and retaining women in Engineering**

The SOE at Tufts benefits from its close relationship with the School of Arts & Sciences. In fact, the SOE was formerly the College of Engineering, joined by the College of

Liberal Arts (male undergraduate liberal arts students) and Jackson College (female undergraduate liberal arts students) in an overall School of Arts, Sciences & Engineering. It was only in 2001 that the name was changed to the School of Engineering. (Tufts University also has several other schools – the School of Medicine, the School of Biomedical Sciences, the School of Dental Medicine, the Cummings School of Veterinary Medicine, the Friedman School of Nutrition, and the Fletcher School of Law and Diplomacy. This close historic relationship between Engineering and Arts & Sciences has had a number of long-lasting implications for the inclusion of women in Engineering:

*The integration of Engineering and Arts & Sciences*

Undergraduate students can very easily transfer between Arts & Sciences (A&S) and Engineering. First of all, Engineering students can take classes in Arts & Sciences, and vice versa, with no bureaucratic hurdles whatsoever. A student from one school can register for a class in the other without petitioning, permission from an advising dean, etc. No money changes hands between the schools when students “cross-register,” so there is no bureaucratic incentive for administrators to discourage students from taking classes in the “other” school. Furthermore, a number of the required courses for SOE students are taught in A&S departments – Mathematics, Physics, Chemistry, and English. SOE students also have a five-credit requirement in the Humanities and/or Arts and Social Sciences, all of which must be taken in A&S. The two schools do not duplicate their courses, so SOE undergraduates, at least, are forced to take courses from A&S faculty and with A&S students. Additional collaboration between the schools is institutionalized through joint majors (e.g., Engineering Physics, offered jointly by the SOE and the Physics Department in A&S), and by the fact that one SOE department, Computer Science, offers an A&S undergraduate degree as well as a SOE degree. Last but by no means least, the two schools are cheek-by-jowl geographically – the main SOE building is physically connected to an A&S building, and is no further from the main academic quad than many of the A&S department buildings. This structural situation creates very permeable boundaries between the two schools, with beneficial effects for all students.

These permeable boundaries mean that the SOE is not isolated, and thus less likely to develop an exclusionary culture of male technical superiority. While it is true that among some students (not to mention faculty), one can encounter the attitude that SOE students are smarter than A & S students, or at least work harder, this has not calcified into an overall culture of the SOE being completely separate from and superior to A&S. A SOE student who takes elective classes in A&S is not automatically regarded as taking the easy way out, and an A&S student who decides to try out an SOE course is not automatically discouraged by the notion that being an A&S student is *prima facie* evidence that s/he would not be able to handle it. It is true that SOE students must complete 38 credits to graduate, and A&S students must complete 34. And it is also true that the requirements for the Engineering undergraduate majors are such that there is less flexibility in their schedules than there is in those of their A&S peers. Nonetheless, a

number of SOE students double-major in one of the Engineering disciplines and an A&S discipline.

One result of the ease with which SOE and A&S undergraduates can take courses and interact with students and faculty from the other school is that the number of students who transfer from the SOE to A&S is roughly equal to the number who transfer in the other direction. In AY05-06, 24 (of whom six were female) SOE undergraduates transferred to A&S, while 22 A&S (of whom seven were female) undergraduates transferred to the SOE.

#### *Integrated housing and other student services*

Undergraduates from both the SOE and A&S are completely intermingled in terms of campus housing, student organizations, student services, etc. This allows students from both schools to get to know each other, and allows administrators and faculty to be aware of issues and opportunities in both schools. The schools share one Office of Admissions, one Office of Undergraduate Education, one Dean of Students, one Office of Financial Aid, etc. Just as the permeable boundaries and integration with respect to courses and other academic activities encourage communication among students from both schools, so does this integration of student services. The opportunities for friendship, informal mentoring, and the exchange of information are obvious.

#### *An integrated faculty*

Faculty can intermingle very easily. The legacy of the many years of integration of Engineering and Arts & Sciences under the overall umbrella of a joint School of Arts, Sciences and Engineering is that much of faculty governance is still integrated. There are several meetings a year of the Faculty of Arts, Sciences and Engineering, where all new faculty are introduced, all retiring faculty are honored, and major non-curricular decisions are voted upon. All faculty committees, except for the two that oversee curricular decisions, are composed of faculty from both schools; in most cases, committee membership slots are assigned by school, so that participation from both schools is mandated. Adjunct appointments for faculty from one school in a department in another school are commonplace.

#### *Leading by example*

There is a demonstrable commitment at the upper levels of the Tufts University administration to bring women into top posts. Four of the eight school deans are now female (SOE, Nutrition, Biomedical Sciences, and Veterinary). Other top administrators are also women (the Vice President for University Relations, the Vice President for Human Resources, the Vice President for Information Technology, the Vice Provost, and the Chief Investment Officer). This helps to create an overall atmosphere and delivers a message that women's abilities and accomplishments are recognized at Tufts, including in fields where men historically had predominated (engineering, information technology, financial investment strategies).

The commitment to the inclusion of women in Engineering predates the current administration at Tufts. By the early 1990s, Dean Abriola's predecessor at the SOE, Ioannis Miaoulis, was championing the inclusion of women by sponsoring outreach programs for K-12 girls, supporting various programs for undergraduate women, and actively supporting the recruitment of a number of female faculty.

#### *The impact on women*

The integration of the SOE and A&S provides a supportive environment for women in Engineering at Tufts. Women in the SOE are not isolated. Both students and faculty have ample opportunity to get to know and to derive support from women in A&S (and the converse is true, as well). The ease with which students can move academically between the two schools has already been noted. If female students do not find a support group directly within the SOE, they have many places to go within the overall integrated structure provided by AS&E. For example, a recent female bachelor's recipient who was very active in the Lesbian, Gay, Bisexual, Transgender (LGBT) community found it to be an important source of support. Tufts has an LGBT Center with a full-time professional director; Rainbow House, part of a residence hall which "provides a 'gay-friendly' atmosphere where students can live and interact;" (Tufts University website: <http://ase.tufts.edu/reslife/ResHallInfo/sgb.htm>); and the Queer Straight Alliance, one of the official funded student organizations.

There is a substantial amount of anecdotal evidence of faculty from the SOE crediting their contacts with faculty and administrators outside of the School as important sources of support. One example comes from Associate Professor Soha Hassoun of the Computer Science Department:

"The close connection between the School of Arts & Science and the School of Engineering has provided increased school-wide support to our faculty. For example, several faculty across the two schools have written proposals targeting the increase in representation and advancement of women in academic science and engineering careers. Two such programs have been funded in multi-year proposals involving several faculty. We have had several unexpected yet amazing outcomes. Interdisciplinary technical research discussions are common (e.g., between a female professor from Computer Science and a female professor from Math about modeling on-chip inductance. A student of the Computer Science professor also often approached the Mathematics professor for technical advice). New friendships have formed among the faculty across the schools. Informal mentoring relationships between senior and junior women have evolved. The involved faculty have a strong sense of being connected to the school as a whole and not just to the School of Engineering. This positive experience has lowered the barrier for our Engineering faculty to pursue further interdisciplinary research activities."

### **(III) Recruiting and retaining students**



### *General outreach and supporting materials*

The Office of Undergraduate Admissions works on recruiting and admitting women into the School of Engineering. Dean of Admissions Lee Coffin describes their efforts:

“Women in Engineering are a targeted group in our recruitment and selection efforts. While we do not run any specific programs for them on the recruitment side, we do proactively include women in our PSAT search parameters for engineers; feature them in our marketing work (a female engineer served as our senior admissions intern last year and described her experiences at Tufts during our welcoming session for accepted students and their parents at Open House in April); and consider gender as a factor in our Engineering acceptance decisions. In fact, the acceptance rate for female engineers (41%) is significantly higher than the overall acceptance rate to the class (27%) and SOE (34%). No other gender group (e.g., men in A&S or male engineers) have a comparable acceptance rate. As a result, women represent 30.6% of the current freshmen class in Engineering.”

In addition to these efforts by Undergraduate Admissions, Tufts makes sure that its electronic and printed materials depict women at all levels in the SOE.

### *Targeted programs that help to recruit and retain female undergraduates*

In addition to the general outreach and recruitment efforts described above, the SOE has two programs, operated jointly with A&S, whose goals include increasing the number of women and members of underrepresented groups in Engineering and the Sciences.

### CSEMS: Computer Science, Engineering, and Math Scholarships

Originally funded by the National Science Foundation in 2002, this program provides scholarships to talented students with financial need in their first and second years at Tufts who are working towards degrees in computer science, engineering, or mathematics. A flyer is sent to high schools advertising the program and eligible students are identified by the Office of Financial Aid; priority is be given to students whose family income make them Pell-grant eligible. Within this cohort, women and underrepresented minorities are given priority. The students are provided with exposure to faculty and graduate student research, mentoring, and study skills through weekly meetings with research faculty, academic advisors, student mentors, and/or academic resources. The program provides scholarships for approximately 28 students in each class. Tufts provides additional financial support to enhance the programming.

### First Year Scholars

Founded in 2002 and funded entirely by Tufts, this program provides an opportunity for students who meet certain eligibility criteria (first generation in their families to attend college; from low-income families; from an educationally disadvantaged high school) to come to Tufts early and take two Summer courses. These courses help them get a jump start on their coursework as well as provide a supportive environment to “learn the ropes.” The program includes 12-18 students/year. Since its inception, the program has included 63 students, of whom 28 were SOE students, 21 of them females.

*Programs that may be particularly attractive to women*

There is evidence that programs that emphasize finding solutions to real-world programs are particularly attractive to women, who may shy away from Engineering programs where the material covered seems too abstract and/or technical. For example, two Civil and Environmental Engineering professors found that when an introductory environmental engineering course included an inquiry-based “open” experiment, which the students designed on a problem of their choice, “females in particular indicated that the open experiment enhanced their learning of basic concepts.” (Joseph R. V. Flora and Adrienne T. Cooper. “Incorporating Inquiry-Based Laboratory Experiment in Undergraduate Environmental Engineering Laboratory.” *Journal of Professional Issues in Engineering Education and Practice*. Vol. 131, No. 1, January 1, 2005. Page 19.) There are a number of aspects of the Tufts formal curriculum, as well as Engineering-related extra-curricular activities, that provide just this real-world component.

Introduction to Engineering curriculum, and/or Engineering mini-courses

In their first year at the SOE, undergraduates must take two half-credit courses in Introductory Engineering from two different departments. Many of these courses have syllabi that include, as a substantial component, projects and other hands-on activities, so that students are introduced immediately to the practical applications of the more abstract material that they will encounter in their Engineering classes. Engineering mini-courses, covering topics such as *Skyscrapers, Architecture, and Engineering, The Way Things Work, Design and Performance of Musical Instruments, and Biomedical Engineering Primer*, -also provide opportunities for students to study “real-world” Engineering.

Educational Paradigms: Engineering Academies

At Tufts University, Professor Chris Rogers of the Department of Mechanical Engineering has conceived a major project-based educational program or paradigm -- the “academy” paradigm – and then implemented it through interdisciplinary collaborations and/or with industry partners.

Academies are programs that enroll both junior and senior engineering students, partnering them with mentors and students of non-engineering disciplines to form multi-disciplinary teams. These teams are charged with problem-solving objectives in a particular area. In academy programs, students learn to work in teams, design for a client, interpret data, communicate their findings, and solve a real-world problem. The programs typically include introductory and advanced course components, as well as undergraduate research components. Enrollment is usually through an application process. To date, approximately 100 students have taken part in these programs at Tufts. More than ten Tufts faculty members have also participated. Funding has been derived from a variety of industrial sources, as well as the National Science Foundation (NSF) and the National Institutes of Health. The academy paradigm is unique in many aspects, particularly in its interdisciplinary focus, partnering of non-engineers with engineers, mentoring structure, and problem-centered education.

Three academy programs are currently supported in the SOE. The Robotics Academy links child development majors with mechanical and electrical engineers and computer scientists to design and build next generation robotics. Since its inception in 2002-2003, 17 of the 40 students involved have been females. This year, the Robotics Academy Team is building a tangible programming language that will allow blind students to program a LEGO robot. The second program developed at Tufts is the Musical Instrument-Engineering Program. This program brings musicians and engineers together to design, build, refine, compose for, and perform on a musical instrument. In this program, students have an opportunity to conduct research for some of the major instrument manufacturers, including Conn-Selmer, Steinway and Sons, and Fisk Organs. Most recently, Professor Rogers co-founded the BEND program (Bringing Engineers into New Disciplines). This new program is partnering engineers with students and mentors in psychology and nutrition in an effort to develop better sensors to study obesity.

#### Society of Women Engineers

The SOE has an active chapter of the Society of Women Engineers (SWE), which is one of the official, funded student organizations at Tufts. In AY05-06, members of the SWE chapter attended conferences; visited a local R&D company; convened a faculty/student dinner with a panel discussion on "Walks of Life"; and participated in an event with the Girl Scouts to help get girls interested in Engineering.

#### NERD Girls

Under the direction of Associate Professor Karen Panetta of the Electrical and Computer Engineering Department, the mission of this program is to show a wide audience of young women and young men how successful these students are as they work together to design and construct an engineering system. The projects are intended to showcase the young women's talents, diverse backgrounds and engineering skills. Professional engineers also consult on the projects. The team's first project was to build an energy efficient, solar-powered automobile, and then to take it to local communities, sharing their experiences with K-12 educators and students. Most recently, the NERD Girls have installed solar panels to power one of the two lighthouses on Thacher Island, off the coast of Cape Ann in Massachusetts. (<http://www.nerdgirls.org/>)

#### Center for Engineering Education Outreach programs

The Center for Engineering Education Outreach has several programs, two of which provide opportunities for K-12 students to be directly exposed to both male and female SOE students. The programs both help to get pre-college students interested in Engineering, and provide SOE undergraduate and graduate students with practical experience in teaching, mentoring, and articulating why they are interested in the field. "The Tufts Engineering the Next Steps (TENS) GK-12 project aims to work with K-12 teachers to help them infuse engineering concepts and activities into their lessons. The project, funded by the National Science Foundation, pairs graduate and undergraduate engineering and computer science fellows with school teachers. TENS consists of four

principal and overlapping components: the preparation and education of fellows, professional development of teachers, school and classroom-based efforts, and curriculum enhancement.”

“STOMP is the Student Teacher Outreach Mentorship Program at Tufts University's Center for Engineering Educational Outreach. Each year STOMP@Tufts places approximately 30 undergraduate and graduate engineering students in K-12 classrooms and after school programs to facilitate engineering education. To date the program has reached approximately 2000 K-12 students.” (<http://www.cceo.tufts.edu/>) From 2001-2002 through 2005-2006, STOMP has placed 108 students, of whom 55 were female.

#### Engineers Without Borders (EWB)

Tufts University has an active chapter of Engineers Without Borders, USA, which is a non-profit humanitarian organization established to partner with developing communities worldwide in order to improve their quality of life. The Tufts chapter, jointly sponsored by the SOE and the Tisch College of Citizenship and Public Service, includes both Engineers and A&S students – yet another example of the integration of the schools. Founded by two SOE female students, the organization now numbers some 50 students, and has sent 16 students, of whom 10 were women, on summer field projects. In Summer 2005 a group of students worked on a water-supply project in a small village in Tibet. In Summer 2006, there were two groups working on conservation and water-supply projects, one in Ecuador and one in El Salvador. SOE faculty serve as mentors to the student teams.

"It's a great experience to be part of a truly interdisciplinary team and try to get something accomplished within three weeks," said Sarah Freeman, currently a graduate student in civil and environmental engineering who served as the first president of EWB at Tufts. "You can't predict what will happen. While you bring your classroom learning with you, you have to be flexible to go through redesign in the field. Of incredible value is realizing the softer, human side of things, to consider the users and builders and their interaction with the design." (<http://ase.tufts.edu/ewb/> and the Tisch College website, <http://activecitizen.tufts.edu/?pid=118>)

#### Undergraduate advising

Kim Knox, the Associate Dean for Undergraduate Education, is part of both the SOE and the AS&E Office of the Dean of Undergraduate Education. She is thus in a position to be in constant contact with her A&S colleagues, which facilitates communication about students. Her time is dedicated 100% to advising SOE students, and she is famous for her mother-hen approach. The close attention that this dean gives to individual students complements the undergraduate advising structure in the SOE, where faculty members advise both pre-major students and majors. This structural set-up provides for lots of individual attention for students. The most recent ABET Accreditation team, reporting the findings of its September 2005 visit, stated that "the advising of students is a strength of the School of Engineering."

### *Formal and informal mentoring*

The SOE has a higher-than-average percentage of female faculty members, a topic which will be discussed below. These faculty members often serve as formal and informal mentors for female SOE students, and help to provide concrete role models of women in Engineering. The SOE also has a professional staff member whose primary responsibility is to arrange and supervise internships for SOE students, and a Director of External Relations whose responsibilities include developing contacts with SOE alumni/alumnae and local companies, organizing career and graduate school fairs, etc. All of these contacts provide a network of potential mentors for students. The fact that there is professional staff time dedicated to overseeing the SOE internships means that students get personal attention as they are pursuing an internship placement, and that the success or failure of their internship is not left to the luck of the draw of which professor they approached for help in arranging one. As it happens, both of these staff members are female, another factor which may help the SOE retain female students.

### *Student profile*

The following profile from the SOE website provides a fitting conclusion to this section on recruiting and retaining female students in the SOE:

Kaitlyn Conroy majored in Civil and Environmental Engineering at Tufts University, graduated in May 2006, and is continuing on to the Master's degree program in the same department. Her research looks at vibration of floors due to trains, earthquakes, and pedestrian activity. She is interested in looking at design of buildings from the perspective of both geo-technical and structural engineering.

Kaitlyn says that as a high school student she did not know that she would become an engineer one day. "Through high school I was good at physics and math, and my high school guidance counselor told me that I might like engineering when I got to college". This idea stayed with her when she joined Tufts. As she started taking classes she realized that she was drawn more towards engineering classes than any other, and was fascinated with her structural engineering. Deciding to pick Civil Engineering as her major was a small step from there.

Besides being a fulltime student Kaitlyn is an Executive board member of the Center for Engineering Educational Outreach (CEEEO) at Tufts. As an active member of CEEEO, Kaitlyn interacts with children of various ages, exposing them to engineering principles and activities like building robotic legos among others. Kaitlyn says that she takes her job of a role model for children very seriously, since it allows her to challenge their pre-conceived notions of being a female engineer. "Showing children what females can do as engineers, is an important and empowering lesson for young girls", she says.

Kaitlyn says that she would like to work in a geo-environmental firm after she graduates from graduate school. "I am not interested in teaching at a college level", she says. "I am

more interested in the design aspects of civil engineering and want to be in a job where I can do that." (<http://engineering.tufts.edu/profile-students.asp>)

#### **(IV) Faculty recruitment and retention**

In the School of Engineering at Tufts, 21% of the tenure-track/tenured faculty are women. Women comprise 36% (4 of 11) of Assistant Professors; 17% of Associate Professors (4 of 23); and 18% (5 of 28) of Full Professors. (See Table 2. Data are from October 2005.) While we are hoping to see these numbers increase, they are higher than average, and they have not come about by accident. At least since the early 1990s, the SOE has emphasized and put resources into increasing the number of female faculty.

##### *Faculty hiring – regular searches*

The SOE has a very active Affirmative Action Officer (AAO), Dr. Margery Davies, who also plays the same role in A&S. In 1996, the School of Engineering and the School of Arts & Sciences created a dedicated, half-time position as AAO for the two schools, instead of having Affirmative Action duties tacked on to an already-existing full-time position. Dr. Davies was recruited from another administrative position at Tufts to become the AAO, and since then was appointed as the full-time Director of the Office of Diversity Education and Development for the SOE and A&S. The Dean and the AAO monitor all steps of a faculty search very carefully, and departments must get approval from them at several points along the way before being permitted to proceed to the next one. At the beginning of the academic year, the AAO meets with all of the search committees to go over procedures and to emphasize the importance of doing outreach to build a diverse pool of applicants.

Proposed position announcements are scrutinized carefully to make sure that their requirements are not so restrictive that very few people would be eligible to apply. Departments are strongly encouraged to place their position announcements in job listings that are targeted to diverse audiences, such as the Society of Women Engineers, the National Society for Black Engineers, etc., as well as in the standard disciplinary listings. Letting the position announcement do all the work is not considered adequate, however. Search committees are also required to do outreach. The AAO provides departments with resource files of contacts that might be able to help them build diverse applicant pools, and confers with individual search committee members when they have questions about how best to approach people for help. All of this advertising and outreach is intended not only to get the word out about a position, but also to create a presence for Tufts and communicate the message that we are serious about building diverse applicant pools in the hope of building a more diverse faculty.

Faculty searches in the SOE and A&S do not have application deadlines, but we do have a “review of applications” begins date, after which the winnowing process starts and decisions begin to be made. (We eliminated hard-and-fast application deadlines about ten years ago, so that our outreach efforts would have the maximum amount of time to operate, and to ensure that promising candidates who surfaced late in the process would

not be eliminated by an arbitrary deadline.) After a search committee has made its “first-cut” decisions, it must pause and have these decisions reviewed by the Dean/AAO before going further. The applicants who make it through the first cut are termed the “Preliminary List.” Search committees are required to submit the demographics of their total pool of applicants, as well as those of the Preliminary List. They also must submit an Outreach Questionnaire, in which they detail the outreach that they have done. This allows the Dean/AAO to get a picture of how much outreach a committee has done, how diverse the total pool is, and whether the demographics of the Preliminary List are roughly comparable to those of the total pool. If a total pool is not diverse, and if the search committee can not document much outreach, the search committee is asked to go back and try harder. In one recent search, the total pool had no females, and the Outreach Questionnaire indicated only that the position announcement had been placed in the standard disciplinary listings. The department was not permitted to proceed to the next step in the search until they had done a substantial amount of outreach, and had documented it.

On the positive side, some search committees have done extensive outreach, and without having to be asked. Professor Diane Souvaine, current Chair of the Computer Science Department, details her very effective approach:

- Look up highly regarded faculty in other institutions.
- Call them, whether you have ever met them before or not.
- Pitch the position you are trying to fill. Only after making the pitch for the specific position, ask them for any names.
- After they give you a list of names, all of which you take down, then (and only then) say that you are trying to build a diverse a possible candidate pool and ask whether there are any really good women and/or persons of color whom they could recommend. Again, take down names. Then ask of all of these candidates, whom do they consider the most promising for the particular position.
- Often, they will rank one of the second group of names higher than those in the first group.
- Often, there is a lot of pointer chasing. Keep at it.
- Then make a personal connection to the candidates. Listen to what will be the real deciding factors for them. Don't take an initial "I'm not interested" as the final word. Find out why they think that they are not interested, and what it would take for them to become interested, and then see if anything is feasible.
- Be willing to call lots of people you have never met before and who don't know you and pitch the job you are trying to fill.

As a testament to the effectiveness of these techniques, in 2003-2004, the Computer Science searches yielded four hires – three of whom were women.

Once the Preliminary List has been approved, a search committee may proceed to the next step of proposing which candidates to bring for on-campus interviews. Again, the Dean/AAO scrutinize these recommended interviews very carefully. The search committee has to send the applications of the candidates whom it wants to interview, as

well as the reasons why it does not want to interview any of the other applicants, to the Dean/AAO. The Dean/AAO review these materials carefully, confer, and often get back to the search committee with questions about why a particular candidate is being recommended. Frequently, the Dean/AAO ask to see the applications of all the candidates on the Preliminary List, so that they can examine in detail this all-important second cut. The Dean/AAO have on occasion denied permission to interview a candidate who did not seem comparatively strong enough, and have also requested that a department interview a candidate who was female or from an underrepresented racial/ethnic group who had clear potential.

Once the on-campus interviews have been approved, the Dean/AAO will try to make sure that the search committee is doing what it can to make the interview candidates feel welcome at Tufts and are given the opportunity to meet people of particular interest. If a candidate in Computer Science, for example, has research interests that intersect with faculty in the A&S Mathematics department, the department will be encouraged to make sure that connection is made. If the candidate is a woman, female faculty from other SOE departments are often invited to informal receptions, meals, or even job talks. When candidates come to campus for interviews, they always meet with the Dean.

After all of the on-campus interviews have taken place, the Dean confers with the department chair and shares her impressions of the candidates. The department then sends its recommendation about which candidate should be offered the job to the Dean/AAO. The Dean/AAO confer, and decide whether to approve the hire, or whether discussion with the department is needed. Once the department's recommendation is approved, the Dean then takes over, offers the job, and handles the negotiations.

Obviously, the regular faculty search procedures at Tufts are a far cry from a department announcing to a dean that they are planning to offer a position to Candidate X, in fact have made a verbal [and legally-binding] offer, and they just want to nail down how much salary and start-up money can be offered. The Dean and AAO are very closely involved at every step in SOE faculty searches, and their input and decisions have a concrete effect on the outcome. In addition, these detailed procedures create the inescapable impression that the Dean/AAO are really paying attention to what happens in a search, which helps to encourage departments to keep diversity in mind at all times while they are doing outreach and making choices.

#### *Faculty hiring – additional aspects*

There are a number of additional aspects of faculty hiring that bear mentioning. The SOE has been quite willing to recruit, consider, and hire candidates who have not followed the “regular” academic career path or who have come from government or industry. This has resulted in the hiring of several faculty in recent years, most of whom have been women. We have also been willing to “go the extra mile” to recruit candidates and get people who have been given offers to say yes. Encouraging calls from the Dean; the offer of return visits to campus; competitive start-up funding; flexibility in start dates; a transitional housing program shared with A&S, as well as other informal help with housing and



information about schools and local services; employment advice for “trailing spouses/partners” – all of these have helped us land candidates.

The SOE has also been willing to hire two people out of a single search when the situation warranted it, and particularly if this would help us diversify the faculty. We will also entertain proposals for window-of-opportunity hires if a department finds an outstanding potential faculty member who might be interested in coming to Tufts. Although we are careful about our budget process to ensure that there is funding for the faculty we hire, and we would not approve a faculty search if we could not see where we would obtain the resources, there is enough flexibility in the budget so that special additional hires are possible. The Provost has been very helpful in this regard, and the overall Tufts administration is ready to “put its money where its mouth is” when it comes to diversifying the faculty.

*Faculty retention – structural support*

There are a number of policies and programs in the SOE that provide support for junior faculty in their quest for tenure.

Dean Abriola has instituted a new course load policy for all faculty hires: the nominal load is three courses/year. All new hires teach two courses in their first year (this is sometimes extended to the first two years, depending on department flexibility). Prior to her arrival, the nominal course load for all new faculty was four courses/year.

There is a junior faculty leave program that gives faculty one semester of guaranteed paid leave during their tenure probationary period. This is often coupled with a grant or fellowship (some of which are funded by Tufts), so that the junior faculty member can devote an entire year exclusively to research.

The SOE also has a mentoring program, which assigns two mentors to each new faculty member, one from the person’s home department and one from outside that department. The concept is that the former can provide appropriate guidance on disciplinary issues and the latter more advice on general professional/personal developmental questions. The Dean also sponsors a monthly networking brownbag of the untenured faculty in the school. This lunchtime series was initiated by an Assistant Professor in the Biomedical Engineering Department, Irene Georgakoudi. The Dean pays for a luncheon once a semester.

The Dean meets with all junior faculty once a year, to get to know them better and to have a sense of how they are doing. In addition to this informal check-in, all junior faculty must be reviewed by their departments and the Dean in their second and fourth years. This is a formal, written review. In the second year, which takes place after the new faculty member has been at Tufts for scarcely more than a year, the review is intended to make sure that the faculty member is basically on track with research and teaching. In the fourth year, the review is more extensive, and is intended to give the faculty member a fairly clear signal as to whether they are on track for tenure, or whether

tenure is in doubt unless there is a dramatic improvement in research and/or teaching. (Although this rarely happens, some faculty are terminated pursuant to a second- or fourth-year review. Others read the handwriting on the wall and go on the job market.) While these review processes are understandably anxiety-producing for junior faculty, they do provide a structure for faculty to get feedback, to have a sense of where they stand, and to avoid falling through the cracks.

Tufts University offers three months of paid maternity leave for biological mothers, and four weeks of paid paternity/adoption leave for all parents, regardless of sex or whether the new child is adopted or biological. The SOE and A&S also have a primary-caregiver policy, wherein a faculty member who declares him/herself to be the primary caregiver of a child can stop the tenure clock for a year. This tenure-clock stoppage can occur twice during the tenure probationary period. While male faculty members have availed themselves of both the paternity/adoption leave and the primary-caregiver tenure-clock stoppage, it is generally accepted that the fact that these policies are in place will prove more appealing to female faculty members, as a group. The recognition of work/family balance issues – both the concrete programs themselves, plus the creation of an atmosphere that Tufts recognizes and supports people who are trying to combine work and family in balanced ways – can be attractive to women.

#### *Faculty retention – informal support*

Finally, there are ways in which the informal support afforded to female SOE faculty can make a tremendous difference in whether they have a positive experience. The integration of the SOE and A&S has already been discussed at length. For female SOE faculty, this integration at the faculty level means that they have many opportunities to get to know colleagues in A&S who can provide them with advice and friendship.

The presence of several senior female faculty in the SOE has had a powerful impact – both through direct help and through role modeling -- on the careers of some of the junior female faculty. For example, in one department, the recruitment of a new senior faculty woman helped provide support to a junior woman who had felt isolated in her position. The senior woman sought out her junior colleague for a series of informal conversations pertaining to prioritization and choices in building a successful academic career. This informal mentoring process led to some tangible changes in the way the junior faculty member allocated her time and to some remarkable success in garnering external visibility and support for her research and service efforts.

Finally, some departments have been able to provide a very supportive atmosphere and concrete support for faculty who are facing work/family balance issues. Faculty members with their own or their children's extremely serious health issues have had colleagues who taught classes for them, department chairs and a Dean who have given them lighter teaching loads, and department chairs who have excused them from all committee work. These concrete instances of collegial support and caring have helped to create an atmosphere in several SOE departments that is deeply appreciated by faculty and seen as something worth holding on to – an important factor in faculty retention.

## (V) Conclusion

The School of Engineering at Tufts University has a better-than-the-national-average record of recruiting and retaining women, both students and faculty. The overall context of close integration with the School of Arts & Sciences and an array of programs and policies as outlined in this case study of the SOE may help to explain this. However, without a carefully constructed control, it would be difficult to maintain that we have hard-and-fast proof that these aspects of the SOE have caused this. Nonetheless, we are proud of our record to date, although we would like to continue to improve it. We are also proud of the programs, infrastructural supports, culture, and climate that we are creating at Tufts, not only for women engineers but for all engineers. Men as well as women benefit, and we are hopeful that the innovative engineering education we are creating at Tufts will lead not only to the continued recruitment and retention of women, but also to the creation of better engineers.

—END—

ACKNOWLEDGEMENTS: We are very grateful for the assistance of many people in the preparation of this article: Peter Boyajian, Erin Cejka, Lee Coffin, Lewis Edgers, Marilyn Glater, Brian Gravel, Soha Hassoun, Kim Knox, Arthur MacEwan, Jeff Pietrantoni, Merredith Portsmore, Robert Rasmussen, Sarah Richmond, Ann Marie Serrecchia, Diane Souvaine, and Kevin Staszowski.