

Balancing on the Tightrope: Maintaining Gender Parity in a Successful Undergraduate Engineering Program

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Abstract This paper focuses on the surprising attainment of gender parity among Industrial Engineering (IE) majors at the University of Oklahoma (OU). In the past five years, the percentage of female majors has varied between 40 % and 58% in the absence of a formal gender equity program. 40% of the faculty are female. We think that general strategies employed to increase retention of students have had a substantial role to play in the department's unplanned success in obtaining gender parity. We seek to identify the most important strategies and to determine the reasons for their success. In 2003, some University of Oklahoma project members began interviewing Industrial Engineering students, both female and male, about their experiences at OU under the auspices of a National Science Foundation Gender Equity grant (Award NSF-GDSE #0225228). Seymour and Hewitt's *Talking about Leaving: Why Undergraduates Leave the Sciences* (1997) suggests that females in the sciences are often victims of weeding out processes in their sophomore or junior year. In IE at the University of Oklahoma, it appears that undergraduates form close bonds with faculty mentors, work on research projects, and actively participate in technical organizations. They also see faculty outside of classroom and laboratory settings at numerous social events. Coded data from interview transcripts will be analyzed to identify aspects of the departmental culture that are conducive to female students remaining in IE until graduation. The role of internships and career fairs will be considered with regard to employment options available after graduation with data from annual

departmental assessment reports . Ethnographic data will be quantified in some instances. For minorities, a small, formal program is in place for recruitment and retention. In 2001, the National Action Council for Minorities in Engineering ranked the University of Oklahoma among the top ten colleges and universities in the US in its production of American Indian engineering baccalaureate degrees. Although the sample size is small, data on minorities will be disaggregated for comparison with gender retention data in IE.

Introduction

The School of Industrial Engineering (IE) is unique in having achieved gender parity in the absence of a formal gender program. In the past five years, the percentage of female majors has varied between 40 % and 58%, well above the national average. Even its recent outcomes assessment reports (Pulat, n.d.; Kumin, n.d.) do not articulate diversity goals. However, the academic unit's articulated goals are student-friendly in stressing the need for good teaching and the integration of relevant topics, such as professional ethics and human subjects research guidelines, throughout the curriculum. Collaborative work among students is encouraged, with problem-solving viewed as a team effort. Faculty members, 40% of whom are female, stress the global scope of the discipline and emphasize the need for an awareness of contemporary issues in engineering practice. Students are encouraged to do internships and to study abroad and their activity is reported annually. In addition, the degree competitiveness of IE students is measured by their performance on the national examination taken during their senior year. What factors have contributed to IE's unplanned success vis-à-vis the culture of science? The culture of science will provide a reference point for the analysis of IE's tinkering with the culture and the variety of social interactions between faculty and students and among students themselves that enable the unit to make nimble steps to maintain gender balance.

The Culture of Science

Seymour and Hewitt (1997), in their path-breaking study of women and minorities in STEM fields, identified a variety of factors that precipitated substantial proportions of these students switching out of the sciences before college graduation. Despite the fact that female participants identified instances of discrimination, they did not view such incidents as an impediment to their progress in science disciplines.

Conefrey (2001) uses Seymour and Hewitt's discussion of discrimination as a starting point to reanalyze some of the authors' ethnographic data while utilizing aspects of her own two-year, ethnographic study in a life science laboratory to examine the dynamics of discrimination in the culture of science. She suggests that after the Science and Engineering Equal Opportunity Act in 1980, which required the National Science Foundation to collect data on the status of women and minorities, the Foundation

described the progression through education and careers as a pipeline (2001: 170-1). However, upon further examination, they discovered that there was considerable “leakage” in the pipeline. For example, in 1995, women were awarded 46.5% of bachelor's degrees, 38% of masters degrees, 31.3% of doctorates in science fields.

Packard and Wong (n.d.) interviewed college women who had majored in science fields for two years to determine the extent to which they experienced a “clash of future selves”. From the interviews, they derived three kinds of clashes: “(1) type of person; (2) lifestyle choices; and (3) purpose of science work”. They suggest that positive and negative images of science compete as individual women contemplate their future, thereby precipitating the clash of future selves. Some of the negative images include time-consuming experiments in laboratories, competition for no reward, science as being anti-family, the need for a greater social commitment, and the need to formulate practical applications of scientific research. They have limited exposure to academic women, limited exposure to multiple images and settings in the field, and a lack of clarity about future careers (n.d.: 12).

Packard and Wong (n.d.: 18) portray the positive image of an engineering student, who finding no exact role models, identified a number of individuals who exhibited aspects of her interests, thereby using multiple components for mentoring. They suggest that female students, in seeking alternative images that allow them to stay in the sciences, move away from the traditional abstract sciences to applied and health-related sciences. Although their sample included eighteen Mid-western white female undergraduates, Packard and Wong speculate that the clash might be even more pronounced among women of color and first-generation college-goers. They conclude that the clash is an institutional issue rather than an individual one in which the former has the power and therefore the responsibility to manage it. In addition, they suggest that a successful mentoring strategy should combine the institutional, family, and individual levels to be successful.

Margolis and Fisher (2002) analyze gender and diversity equity issues in the Carnegie Mellon School of Computer Science. The authors examine girls’ exposure to computing at the elementary and high school levels and within the home to determine why female majors were underrepresented in Computer Science. They also question the embedding of Computer Science in Mathematics and Science rather than in the context of its social relevance and practical applications. To recruit more minority and female undergraduate majors, they suggest that students should not be admitted solely on the basis of test scores and grades and that faculty need to engage in more interaction with students. Using insights from their research, they showed that Computer Science could achieve greater diversity while continuing to admit highly-qualified students.

Inadvertant Tinkering with the Culture of Science?

The School of Industrial Engineering at the University of Oklahoma began experiencing a substantial increase in the number of female majors in 1996 when the percentage began to climb by six percent per annum (Harris et al, 2004). This increase,

which coincided with the hiring of a third female faculty member, came as a surprise to faculty in the unit. Now, diversity goals have been articulated in the College of Engineering's 2005 strategic plan (Porter, n.d.).

The pinnacle of the increase occurred in 2001 when the proportion of female students enrolled in the School of Industrial Engineering reached fifty-eight percent. Table 1 indicates the percentage of baccalaureate degrees awarded to women and minorities in Engineering as a whole and Industrial Engineering in particular at the University of Oklahoma and nationally during the 2001-2002 academic year.

Table 1. Percentage of Bachelor's Degrees in Engineering or Industrial Engineering Awarded in 2001-2002 to Different Groups.

	OU		National	
	All Eng.	IE	All Eng.	IE
Women	22.4%	55.6%	20%	36 %
African-American	7.7	16.7	5	6.9
Hispanic	4.0	5.6	6.5	11.8
Native American	2.0	5.6	0.5	0.5
Asian-American	11.7	5.6	11.5	8

OU data from the National Center for Educational Statistics (www.nces.ed.gov) for 2002. National data from "Undergraduate Discipline Choices – Preferences by Gender, Minority Groups and Foreign Nationals," *Engineering Trends*, (www.engtrends.com), August 2003.

Except for Hispanic students and Asian-American students in IE, the percentage of women and minorities in Engineering as a whole and in Industrial Engineering at OU exceeds the national average.

A variety of theories have been advanced by project members about the high percentage of female undergraduate majors in Industrial Engineering since the project's inception. Among the theories are:

- that it coincided with and has been influenced by the increase in female faculty;
- and/or that the nature of the discipline is more social-science oriented and that this is attractive to relevant groups;
- and/or that the College of Engineering's embrace of a more collaborative research model was conducive to attracting women students and faculty.

The goal of the project is to elucidate the complex web of effects attributable to these and other possible explanations. The ethnographic data for this paper are derived from interviews conducted with forty-one Industrial Engineering majors during the 2003 spring and fall semesters. Table 2 shows the participant demographics.

Table 2. Participant Demographics for the Data Set Interviews

Group	Number of Participants
Female	23
Male	18
Latino*	8
African-American*	4
Native American*	2
Asian & Asian American	4
Other International	3
White	19

*These groups are designated as URM in the student identifiers for quotes; the other groups will be designated non-URM. We are not using specific cultural identifiers with the quotations to preserve student confidentiality.

Analysis of ethnographic data focuses on the following: faculty-student interaction inside and outside the classroom; office visits; research projects, internships, and job placements; social gatherings; and, interactions among students. Student quotes include editorial explanations or categorizations of personally identifiable data in square brackets. Words in parentheses indicated best possible transcriptions.

Industrial Engineering appears to have a very positive academic climate in which faculty and students can prosper. Students were very positive about their interactions with faculty both within and outside the classroom. Rhoads describes the how faculty and students utilize the physical space occupied by the School of Engineering:

The department's physical location is unique in comparison to many other departments or institutions. The majority of the faculty offices are located in a single sub-hall, off the main thoroughfare in one of the engineering buildings. Within the sub-hall, the majority of faculty offices are situated behind the desk of a single office assistant, who is student friendly and always welcoming. This assistant typically knows the approximate whereabouts of the faculty and shares with students ideas of how best to contact individual faculty members. Typically, office doors are open while faculty members are working on various projects, not just during their office hours (Harris, Rhoads et al, 2004: 189).

Thus, the physical layout of the department and the central placement of an office assistant facilitate student-faculty interaction.

Student-Faculty

The classroom is the locus of pedagogical activity for undergraduates majoring in Industrial Engineering with lectures, individual homework, and group projects.

However, outside of classroom interactions are at least as important as interactions inside the classroom.

Thirty students spoke with enthusiasm about their interactions with faculty outside the classroom. They found that faculty members connected with them as individuals, remembering their names and research interests. Students appear to have bonded with the faculty. In many instances, it was female faculty for whom they expressed great admiration.

There were several instances in which students indicated how well faculty could relate to them on an interpersonal basis:

I'd met probably five of them [the Industrial Engineering faculty] just from being with [a relative] going in to turn in papers and stuff like that . . . They were really nice and really friendly and I'd see them later in the hall and they (said) "Oh, hi [participant's name]". And you know they knew who I was immediately . . . it really made a difference I guess. (URM female junior)

When I was new to the IE program, no one really knew me as far as the professors. But as you start taking their courses and hanging around in, you know, [the Engineering building] on the second floor. You know professors say, "Who are you?" I say, "I'm [participant's name]. I'm an IE", and they say, "Oh, nice to meet you. Tell me a little bit about yourself." And, and so, you know, gradually they get to know you. (Non-URM male senior)

So whenever I go see her [IE faculty member], it's just, you know, either chat or find out about any questions I may have about internships or something like that. With my other professors it's for the most part just help with the class and stuff like that. (Non-URM female sophomore)

These communications in which a student's interests are identified facilitate student involvement in collaborative research.

Some faculty are admired because of their ability to be good advisers:

He [an IE professor] basically talked me into it. I really am into [an area of Industrial Engineering]. That's probably going to be my area of specialty later. . (URM female junior)

I think it's just, they're [IE faculty] really great. I think, even in comparison to other engineering schools, I think, that they're just great. I think they all seem like they care, you know, about what you're doing. They don't just, like, get up there and teach and then go home at night. (Non-URM female junior)

This student places value on faculty engagement beyond the regular work day.

One student believed his retention in I.E. was due to faculty efforts:

. . . a lot of 'em [the IE faculty] are very involved with the students, it seems to me.. I almost left here twice, and, you know, the faculty was good. I felt like, you know, they didn't push either one, either way or another. . . They wanted me to stay. . . They let me know that I, that they knew, who I was. (Non-URM male junior)

There were a few majors who were not enthusiastic about interacting with the faculty although not negative about the program:

Probably, generally no. I mean, if I see 'em [the IE faculty] around, I'll say hi to 'em, you know, and shoot the breeze. But that's about it. (Non-URM male junior)

Clearly, the faculty cultivate interaction with students rather than avoiding it. However, some students would prefer to maintain a degree of distance.

Office Visits

Students visit faculty members during formal office hours or drop in when they find faculty in their offices outside of designated office hours. Faculty are open to having students visit them, even when they are engaged in research and other activities. The tenor of office visits ranges from the formal to the informal.

This student is more formal in faculty interactions:

. . .one thing that's really nice though, is the office hours. Whenever I go to the office hours, they [IE faculty] always seem willing to go through, you know, whatever problems you're having. And I thought that was always really nice.(URM male sophomore)

Another student's interactions are more informal:

Yeah, I work with her [IE faculty member], too, and [another IE faculty member]. I work with them too and I talk to them all the time because I'm working with them. But just to chit-chat and stuff. I see [IE faculty member] a lot. I don't know if it's daily, but their offices are right there so I'm always saying hi or whatever and stuff. (Non-URM female senior)

Her interactions are both research-related and personal. With regard to research, she is interacting with different mentors to benefit from their areas of expertise as Packard and Wong (n.d.) describe in their paper.

When asked about office visits, one interviewee responded with some reservations:

Not very often. They [IE faculty members] tend to be sort of busy when other people approach them with problems. But I sort of see going to them more as for problems that I have. . . Since I don't like to go to people for problems and like to figure it out myself, I don't really go visit them.
(Non-URM female junior)

However, they are not negative about their interactions with faculty. They just seek to have them more confined. These students may not be as invested in a collaborative model for teaching and research, but still can negotiate their mobility through the undergraduate program.

Office visits provide students with the opportunity to discuss questions related directly to the course they are taking, to get acquainted with the professor, to explore aspects of Industrial Engineering as a field, and to discuss career opportunities. Professors are accessible and seem to encourage these interactions, thereby creating a more cohesive social environment. In a related paper, Lancaster et al (2005) suggest that female students commented more frequently about their office-hours-type interactions with faculty than male students.

Research Projects, Internships, and Job Placements

Students have a variety of opportunities to work on research projects with faculty, to engage in internships in industry, and to learn about jobs being advertised in e-mail messages from the School of Industrial Engineering.

. . . actually I just interviewed with [a large company] from an e-mail that [an IE faculty member] had sent out and I forwarded my resume to the guy that she said to forward it to. So I just interviewed with them yesterday. (URM female junior)

So I felt like, you know, I was really impressed, for one, that she [IE faculty member] took the time to get to know all the students and it made her a lot more accessible, I felt like, so I've gone to her office a couple more times, talking about internships or the master's program. (Non-URM female sophomore)

But really, just now, I'm starting to relate a lot more with [an IE faculty member] because I'm doing the IE research with her. So, I'm helping her with some research. But I feel like I relate quite a bit with a lot of professors. (Non-URM male senior)

Research projects and internships give students more exposure to areas of IE. The former provides publication opportunities that improve student prospects for entering graduate school. The latter improves students' employment prospects.

Social Gatherings

Many students mentioned attending an annual banquet, picnics, and activities in technical organizations. In addition, ten students indicated that they had been invited to lunch by an Industrial Engineering faculty member. Only two students indicated that they had not attended this lunch. Certainly, that sets a positive tone in the School of Industrial Engineering.

Interactions among Students

Students observed that they engage in considerable interaction with fellow IE students in the classroom in conducting group projects and engaging in other activities. This is especially the case when they are taking the same upper-division courses and therefore have the same schedules. However, based on age, this non-traditional student prefers to interact with graduate students:

Well, I get [along] very well with graduate students, I think better than undergraduate students. I mean first of all I'm older than most of them. Like, very much older than most of them. These kids come out of, you know, their degree at 21 and I'm [a non-traditional student], so there's a, there's a gap in age. (URM male alumni/graduate student)

In a male student's narrative below, he indicates friendships elsewhere in the College of Engineering rather than in I.E.:

Well, in IE, the only time I interact with them [other undergraduate students] is when I see them working on group projects or in class, or walking around campus. And from time to time at a party or something. But most of my friends are in [other engineering department]. (Non-URM male senior)

Two male students have, for the most part, confined their interactions to attending class, being involved in study groups, and socializing with friends from IE:

I mean I live in [town]. And so that's quite a drive and everyone else lives in Norman or on campus. And so outside the classroom I usually mingle with two or three students. [Student name] lives in Oklahoma City, so that's halfway for me. So yeah, we interact a lot. And a couple other IE students. But it's not like a set thing that I do every weekend. But I mean, you see them throughout the week so much that you feel like you mingle with them already. So weekends is kinda pushing it. You wanna be, you know, with yourself and have time with your family and so forth. (Non-URM male senior)

I mean, I have three people in my study group and they're like outside friends too. We hang out, we do things and, when it comes to school, we

take care of school work and when it comes to golfing we go out and have fun. . . (URM male senior)

This female student and her friends exchange information to minimize competition for internships:

Well, I don't see [competition] in IE like hardly at all. A bunch of my friends were interviewing yesterday for that. . .[large company] internship and apparently they're only hiring like two people. . .I told all of them [my friends], you know, "good luck!" I hope you do good. And we called each other, you know. Like the first person that went in out of my little group of friends called me and said, "You know, this is what they asked me". And then, like I called the next person. This is what they asked me. And then I ran into this other guy on campus and told him. He was like going up to interview. (Non-URM female sophomore)

Another female student's comments evoke the image of a family or community setting in describing an IE social gathering:

I just went [to] the . . .IE fundraiser on Friday and it seemed like such a tightly-knit group of people and it's just like a huge family. You know, they can joke around. They can do whatever. I was like you know, excellent. I know people in their major, you know, there's so many different types of people that they never say oh we never had lunch with our professors, you know, because [an IE professor] actually takes the time and is willing to go out there and meet with her students. And I really think that's, just a really good experience. Just being able to talk to her because a lot of the students (and I find myself). . . want[ing] to know their teachers and their professors. (Non-URM female sophomore)

It also seems that her relationships with students provide a means for becoming acquainted with members of the faculty.

In the two cases below, these young women's friendship networks exist within the College of Engineering.

Well, I guess mainly . . . I've formed . . .friends[hips] within IE and some other engineering majors. (Non-URM female sophomore)

And then I guess . . . last year I started hanging out with more IEs, or just engineering students, period. (URM female senior)

Male students appear to have more relationships off-campus. Female students often use family imagery to describe the atmosphere and interpersonal relationships in Industrial Engineering and seem to engage in activities more connected with the College of

Engineering and the University. A similar gender dichotomy appears to exist between the two underrepresented minority students quoted above.

Participation in Technical Organizations

Some female students discussed participation in the Society of Women Engineers as a context in which they met IE faculty members:

Like when I'm in SWE, there hardly has been anyone who is in SWE drop out of the College of Engineering because we keep women involved and keep everyone excited about being in there and it's, I think for any engineer, about how accepted you feel and like whether you feel confident and comfortable with your surroundings. (URM female junior)

Well, actually I went to their first meeting and I didn't feel like I was welcome, so I didn't go back. I mean, they didn't do anything, but it was like they already knew each other. So they didn't. I tried to talk to them, but they weren't really that friendly. So I just didn't go. (Non-URM female junior)

These two young women have totally different perspectives on the functioning of the Society of Women Engineers (SWE). One participates fully and the other did not find it to be a comfortable niche.

While bonds appear to be very strong between faculty and students, they appear to be less so among students. However, faculty-initiated activities such as teaching and research create the structure in which students collaborate with faculty members and interact with each other. Upper-division students appear to be more independent.

CONCLUSIONS

Clearly, the University of Oklahoma's School of Industrial Engineering has made great strides in creating a positive, collaborative atmosphere for the benefit of students and faculty similar to Carnegie Mellon's accomplishments in Computer Science. Based on ethnographic data, IE seems to have improved the culture of science by embracing a collaborative model. Faculty members are intensively engaged with their students as individuals and as future engineers. They integrate group projects into the curriculum which inspire the formation of study groups outside of class. They involve students in a variety of research projects and internships and technical organizations. The faculty also sponsor various social gatherings throughout the academic year. This is conducive to maintaining a diverse environment within IE, a constant balancing act, and preparing students for diverse work and educational environments in the future.

To a large extent, all groups of students, including women, minorities and international students embrace the collaborative model. However, female students use more family imagery in describing it. While male students also embrace the model, they

have a greater tendency to work on their own or with fellow students rather than with faculty members. Underrepresented minority students are so integrated into the collaborative model that it is difficult to distinguish them from other non-underrepresented minority students. Nevertheless, gender and URM parity, once achieved, have to be carefully monitored and maintained.

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