

Explaining Faculty Involvement in Women's Retention

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After a period of rapidly increasing female enrollments in engineering (from the mid 1970s to the late 1980s), the percentage of undergraduate degrees earned by women climbed very slowly and has been stuck near twenty percent for more than ten years. Without more directly confronting and responding to a relatively unchanged set of cultural and institutional factors, gender integration in engineering may have gone about as far as it can. The research described in this paper helps to fill in the picture of the engineering faculty, whose role(s) and role performance(s) are generally assumed rather than examined in most research on the undergraduate engineering experience. Based on interviews with 100 faculty, administrators, and student support professionals at five campuses, I describe a variety of faculty views toward the teaching of engineering generally, and toward different demographic groups of students. I describe the variety of contexts within which engineering education is conducted, and their influences on faculty attitudes and behaviors. I move from the national level to the university or the college, which affects faculty life and their views about teaching and students. Locally, I emphasize the department, in which cultural and organizational factors come together most immediately in faculty lives. Finally, I suggest some individual faculty characteristics that help explain the variation in outlook and behaviors among colleagues in the same departments and institutions.

The literature suggests that the behavior and attitudes of faculty have an impact on the educational success and even the retention of their students. Although engineering faculty members are important actors, through their teaching, advising, and designing of curriculum, their professional lives tend to be described at the methodological extremes of either multi-disciplinary, national faculty attitude surveys or participant observation accounts centered on students' lives^{34, 10}. There is little available that focuses on the culture of U.S. engineering educators and the social structures in which they lead their professional lives.

Faculty behaviors and attitudes undoubtedly have a significant impact on nontraditional engineering students' decisions to remain or leave. An expanding literature details the kinds of academic settings and experiences associated with a positive student outcome²⁸. Teaching and advising obviously affect a student's experience, while curricular development and revision have a less direct impact.

Faculty figure as teachers, advisors, and curriculum designers in discussions of influences on undergraduate retention^{30, 20}. Leading critics of engineering education agree that the "weeding" impact of traditional curriculum and pedagogical approaches of engineering courses has a disproportionate impact on nontraditional students, who may view the climate as confirming that they are not welcome members of the student body. In addition, gendered patterns in the student role contribute to different interpretations of similar experiences among

women than among men. For example, women students tend to expect higher grades of themselves than do men, and thus are more likely than men to view the same grades as a sign that they are not well qualified to succeed in their selected field of study¹⁶. When faculty adhere to traditional grading practices (such as the imposition of curves), they have a differential impact on women students.

Faculty differ in their views of, strategies for, and success at creating an atmosphere that fosters learning.¹² The subject matter of projects and problems, the fit between pedagogical and learning styles, and classroom "climate" have each been discussed as influences that affect retention, particularly the retention of students of color and women students. Faculty practices frequently mentioned in the retention literature include: the use of study and project groups, exam construction, time pressure on tests (and tactics for neutralizing it); incorporation of examples and assignments respectful of a diversity of student learning styles; making connections between technical and scientific problems and their social contexts; the use of the curve (or alternative bases for grading); the weighting of lab work; the role of critical thinking; reduction of student's sense of anonymity; and the style of feedback in the classroom. Faculty also affect the pedagogical techniques of graduate assistants, in labs, grading, and other activities they may be assigned. It will be faculty, if anyone, who will reconfigure courses to improve learning⁵, or reconfigure curriculum to make engineering more real and more engaging during the first semesters of coursework (when attrition rates are highest).

Method

I conducted semi-structured interviews with faculty, academic administrators, and student support staff at five schools in the Northeast. At two of the institutions I visited labs, and attended some tutorial sessions and staff meetings. At a third, I audited a one semester senior-level Computer Assisted Design course in Mechanical Engineering. I also conducted participant observation at these institutions and at conferences on engineering education. I visited five additional sites to interview key administrators and faculty from underrepresented groups. I spent two weeks at a traditionally black university, sitting in on a variety of undergraduate engineering courses, as well as interviewing a small number of faculty and academic administrators. The field work was conducted from 1991 to 1997.

Constrained to preserve the anonymity of the schools included as well as the individuals interviewed, I have tried to follow Becker's admonition to include only the descriptors that figure in my explanations of the patterns I found². *Multiversity* is a large engineering school in a large suburban public university; *Tech* is a large engineering school in an urban technological institute; *Friendly* is a small urban engineering school within a small church-affiliated college; and *High Power* is a large engineering school in a middle sized private university in a college town. *Traditionally Black* is part of an urban university with a long history of training large numbers of engineers. The institutions and their engineering programs vary in prestige, in the proportion of students in graduate vs. undergraduate programs, and in the configuration of engineering disciplines among the departments. They vary in the stability of their enrollments; some engineering programs have been in trouble because of declining applications. They also vary in their racial, ethnic, class, sex, and national origin student demographics.

I requested interviews of all female faculty, and all Latino, and African American faculty, as well as a fraction of junior and senior male faculty from other racial-ethnic groups. Most interviews were between 60 and 90 minutes long. Following the "grounded theory" approach developed by Glaser and Straus, I pursued a research strategy in which the questions I posed evolved through the course of the research.⁹ Furthermore, given my selection criteria for interview subjects and concerns about the representativeness of those who agreed to participate, it is more appropriate to think of these individuals as informants, in the ethnographic or anthropological sense, rather than as respondents. The design more closely resembles a "naturalistic inquiry" than a survey;⁸ the findings of qualitative research such as this study are more appropriately judged by a criterion of "credibility" than by the "validity" sought in quantitatively-conceived research. In light of the changing interview questions over time and the inappropriateness of generalization from these "informants," findings are presented qualitatively rather than quantitatively, and I include only general characterizations of the relative frequency of one pattern or another.

The methodology aimed at developing an understanding of the social worlds of the faculty members interviewed – both their departments and institutions. Attending to these "nested" layers is essential for a powerful understanding of faculty life in general and teaching related ideas and behaviors in particular.^{15,35} A multi-layered approach is methodologically unwieldy, however; it more typical that researchers "hold constant" one or more of the organizational levels.³³

In the interviews, engineering faculty reflected on the student experience, and on the everyday realities of lives as faculty members. I asked about approaches to common pedagogical issues, and possible links between these practices and the retention of women and students of color. Interviews also explored views of group differences, as they might pertain to the academic experience, and ideas about "climate" and its relation (if any) to retention patterns, particularly in underrepresented groups. We discussed attitudes toward various schools of thought on curriculum and curricular change.

The availability and willingness of individuals to participate in the research was undoubtedly related to their interest in the retention of nontraditional students, as well as their trust in the confidentiality of their comments. Several asked for a detailed description of my relationship to the administration of their institution, others asked about my funding and the ownership of my data (my only support came from internal funding at Montclair State University). It was not uncommon for professors to not reply to my first request for interviews, and some did not reply to repeated contacts. Nonresponse and nonparticipation were not predictable from individuals' interest in teaching or hostility toward the project (as it was perceived): some individuals were glad to take the time to set me straight (not their wording, but clearly their motivation), while several people identified as campus leaders in teaching, advising, or other retention related areas never acknowledged my communications.

Two men of color explicitly refused on the grounds of the charged nature of the study; I ultimately convinced the tenured one to speak with me. I also interviewed two men who had been denied tenure. In my request for participation, I offered to conduct the interview away from the office. Three women, all untenured, accepted my offer (two U.S.-born whites and one an

Asian immigrant, at two schools). There were both men and women who were unwilling to have their interviews taped, and a few asked me to shut off the tape recorder while discussing a particularly charged topic.

After a description of and a warning about "the" culture of engineering education, the paper turns to a presentation of commonly encountered faculty views of engineering education, the range of strategies individuals used to meet teaching challenges, and views of nontraditional students in particular. Organizational factors that influence faculty decisions about their involvement in undergraduate teaching responsibilities are described, with a particular focus on the department. Examples of individual sources of variation are provided, and the paper ends with a set of recommendations for academic leaders committed to involving their faculty in initiatives for changing undergraduate education.

The Culture of U.S. Engineering Education

Walking through engineering departments, one sees coats and ties much more often than in other departments of the same institution. This greater formality may be because engineering faculty are more likely to be meeting with corporate representatives either on or off campus. At most institutions with engineering programs, the engineering faculty are seen (usually accurately) as more politically and culturally conservative than faculty in other disciplines.

Engineering professors in the United States have generally chosen teaching rather than a more lucrative career path. Doctoral candidates have often spent time in engineering practice before returning to school and then joining faculty ranks. Part-time consulting is one way that faculty shrink the economic gap between these paths. Faculty also host corporate visitors who are recruiting future graduates, sponsoring the study of some of their own employees, or collaborating on some aspect of an academically-based project. Most successful engineering students (at every degree level) will go into private sector employment. And many (or most) successful engineers are promoted into managerial positions by mid-career. Thus, a pro-business orientation is not surprising among engineers, including faculty.

Those from the U.S. have been trained in largely white, male settings; those who went to school before the mid 1970s were trained in virtually all-male programs. Racial/ethnic and gender diversity is even more rare in master's and doctoral programs. Subsequently, the demographic makeup of the professoriate itself is among the least diverse in academia. Most women, African American and Latino faculty who spoke with me reported experiences in the 1990s that are usually described in research on sex desegregation in the U.S. during the 1970s. Racism and sexism that remained by the 1990s was typically practiced in more subtle ways.⁴ Some younger faculty who moved from graduate programs in the American West thought that more old-fashioned views among senior colleagues were a regional rather than a national pattern. A junior woman at *High Power* reported that all her male colleagues' wives were full time homemakers, freeing the men to pursue their professional challenges in a way that neither single nor married women could do. However, a junior man in another *High Power* department saw this as a generational difference, reporting that his junior male colleagues had greater time demands related to their family roles than older colleagues had ever experienced. The accuracy of these perceptions is unknown, but the belief in their accuracy affected junior faculty perceptions of

pressures and expectations from their colleagues. It may be the case that if a particular discipline draws relatively more conservative people, it may be more likely to draw people with a traditional gender division of labor at home. If so, it would explain the perception that one works among colleagues who expect research productivity unfettered by household time demands.

The conservatism of engineering faculty has another, perhaps little perceived, impact on experienced faculty who are relatively liberal. They are used to defending their positions from criticism on their right but less used to considering challenges from more liberal positions than their own. For example, a mid-career white professor at *Tech* had a *Sports Illustrated* swimsuit issue screen saver on his office computer. Because he was more supportive of women in engineering (as a teacher and advisor) than many if not most of his colleagues, he was comfortable with the screen saver - he was confident that he was sensitive to women's issues.

Among the faculty I spoke to, the older men with liberal macro-politics tended to be close to their conservative colleagues when it came to campus politics and views about their profession and training for it. For example, faculty pride in the rigor of engineering training makes pressures for student-friendlier practices suspect. Points of comparison other than immediate colleagues are often industrial contacts and colleagues in other technical fields. Indeed, (especially at larger institutions, where personal relationships across disciplinary lines are less common) colleagues in the liberal arts may serve as a negative reference group for engineering faculty. This probably influences and is influenced by the views liberal arts faculty hold about engineers.

Historically, the perspective on attrition has been one of "weeding out" the inadequate students. Tough introductory level courses are used to identify and remove students who do not have the potential to succeed ultimately in engineering. This is sometimes called the "boot camp" approach, a reference to the Marine Corps' use of basic training to identify and remove recruits who are not tough enough to become Marines. While the weeding role of first courses is not unique to engineering, it is more familiar to engineering faculty than to those in most disciplines. While both Hacker¹⁰ and White³⁴ used boot camp terminology, the faculty that I interviewed did not.

The increased use of "weeding" rather than "boot camp" as the label for this strategy allows faculty to view themselves as leaving behind a masculinist and military model for engineering education. However, weeding is functionally similar to boot camp practice, despite the rhetorical difference. Whether the rhetoric of weeding is articulated or not, traditional teaching practices and curricular design keep weeding alive. Climate research indicates a continued student perception of engineering classrooms as relatively chilly.²⁷

Psychological and social factors are essential to the practice of industrial and much environmental engineering; it was not unusual for me to be told (by engineers from the four core disciplines) that these fields aren't "really" engineering. They explain the higher numbers of women in these fields by the presumably greater interest in the subject matter for those socialized in traditionally female ways. The labeling of industrial engineering as a marginal field in engineering preceded its inclusion of large numbers of women, but now the presence of women may help perpetuate the label.

A Caveat: Limits to "the" Culture of Engineering Education

While the concept of a "culture of engineering education" is heuristically useful, it invites oversimplifications of reality. It emphasizes traditional views, and encourages us to ignore the potential impacts of newcomers from diverse cultures, and from younger cohorts. It underestimates the impact of historical events and trends. Although this warning obviously applies to any occupational study, it may be more salient here because non-engineering faculty tend to stereotype their colleagues, or at least to practice "statistical discrimination" in a generally unselfconscious manner.

Despite their business-suited, clean-shaven, "pocket protected" caricature, engineering professors are not so monolithic nor so different from faculty in other disciplines. For example, scholarship and service compete with teaching obligations. Like others, engineering faculty vary in how they resolve or respond to this competition.

Cultural differences among engineering disciplines and settings should be explored rather than treated as invisible or insignificant. Practicing chemical engineering for an oil company, wearing a hard hat and functioning with an all-male blue collar workforce is different than being an electrical engineer who works on and around computers in settings wholly peopled by white collar workers. Similarly, being a student of engineering is obviously a very different experience if one is at West Point (the birthplace of U.S. engineering education) or at Howard University (a large, urban, historically Black institution) or Swarthmore College (a small, suburban, historically Quaker school), for example. Even among engineering programs at institutions that are of a similar size and sector, significant differences in experience may be related to region (e.g., Rice University in Texas and Dartmouth College in New England).

Thus, variations among departments and institutions were typical rather than anomalous. Departmental cultures often differed within the same institution. Indeed, in larger institutions faculty were sometimes unaware of the extent to which they differed from their colleagues. They varied in the dominance of the traditional belief in a teaching approach based on the goal of "weeding out" poor prospects (the non-militaristic metaphor otherwise equivalent to "boot camp"). However, in the absence of signals to the contrary, faculty often presumed that traditional engineering cultural views remain dominant.

Common Faculty Beliefs about Engineering Education

During faculty interviews, I encountered a variety of common beliefs about students, faculty, and programs that have a chilling effect on faculty involvement in retention-related activities. While they are assumed by many faculty to be dominant, these beliefs are certainly not universally held. Nevertheless, they are rarely discussed, and so those who *perceive* them as widely held may be discouraged from speaking up to question them. Only rarely did I encounter someone who thought these beliefs were no longer common. They were voiced even on campuses with active, long-term, public discussion of the problems of student retention and the national focus on integrating the engineering profession.

An exiting assistant professor at Friendly reflected on the generally lower caliber of students since his undergraduate days (about twenty years earlier):

I asked myself a lot [when I started teaching], “Is it me or is it them?” I talked to a lot of people and became clear it was them. The average student is not as well prepared as the average used to be. [There were always both extremes,] what's different here is the average. I had to tune myself to a different working life, these aren't people who are going on for a Ph.D., to be research scientists. For the most part, these are going to be the “grunts.”

From this point of view, the traditional ways of educating engineers are impossible because the students differ so from the past. For example, another, more senior Friendly professor mentioned that incoming freshmen did not know how to solve equations. Thus, a lack of innovation in one's teaching was not seen as the fundamental source of a lower quality “product.” However, viewing the graduates of his program as doing only low-level engineering work allowed the exiting professor to avoid the ethical challenge of passing incompetent engineers forward to graduation.

Faculty varied in their beliefs about the fairness and the practicality of adding curricular and pedagogical revision to their established workload. Most faculty did not see improving student retention as an individual obligation nor a clear departmental objective. A departmental leader at Tech (himself an older faculty member) said, “a lot of our older faculty can't seem to accept [the shift in admissions away from white, U.S. born students from strong high schools].” He accepted the changing admissions profile, but felt the institution should provide compensatory training. At every institution, some of the senior people expressed the view that an administrative decision to change the incoming students was fundamentally mistaken, and therefore held that faculty have no duty to participate in finding a way to make it work.

Ironically, few faculty expressed concern that poor *teaching* might lead to substandard graduates. While the departing Friendly professor considered that there were a number of really good teachers in the department, he added “we have a few who are substantially below... [due to professors'] culture differences, language differences, attitude problems. [Students] can't go to them for help. Students obviously suffer from that, but they give good grades so students don't complain.”

The following ideas frequently appeared, as assumptions of the respondents themselves or their perception of common beliefs among their colleagues:

Those students who leave probably are making the right decision: they shouldn't be in engineering.

Attrition is a sign of programmatic or institutional rigor – “weeding” is appropriate.

Disciplines (e.g., industrial engineering) that have been relatively successful in attracting and keeping students from one or more nontraditional groups are not *really* engineering disciplines.

An interest in undergraduate teaching is a sign of professional weakness in an individual, indicating an inability to do well as a researcher.

If our star students do well, our curriculum and pedagogy work well.
Administrative statements about the importance of teaching and advising are only lip-service.

Innovations should be guaranteed to be effective before scarce resources (e.g., time) are invested in them.

Salient knowledge claims of social scientists and educational researchers are essentially suspect.

Changing a system that works is asking for trouble (for example, bridges will collapse if we change the way that we train engineers).

The system works well enough (slight changes in a program's numbers are enough to stop focusing on this problem).

Strategies for Effective Teaching

Whether committed to traditional teaching or more progressive, most faculty had done some thinking about how their teaching. Nearly all faculty interviewed for the present study felt that learning their students' names, or some other way to show they know the individuals, would be good for the students. It would make students feel more connected to their studies, and more likely to approach the teacher for help when needed. But faculty often perceived their classes as too large for this to be possible. Many professors commented that they learn the names of the best and most troubling students. Some mentioned that they always find learning names easy, others said this is something they are poor at (not just with students). The rare professor spoke of making a special effort to learn the name of each student. Some studied student photos, while one regularly made a video of the students early in the semester. With class sizes that varied (among and within institutions) from a dozen to several hundred, learning names was not an equally practical goal in all situations. Those who learn names easily were grateful for that capacity, and others regretted its lack. Given the variety of other demands on faculty time, and the lack of any formalized recognition of how helpful this might be, learning names was not a high priority for most faculty. An Eastern European immigrant at High Power told me that he does "try to learn names, but that is as part of the whole of connection to students, meaningless if you don't know what they [the students] are about." A senior professor at Tech accepted his general inability to remember names, but gave examples of slipping in some reference to a student's life (what s/he "is about") in order to make a personal connection.

While the utility of making a personal connection with students was not controversial, other strategies were a source of internal or departmental conflict. Some professors had decided to cover less material in their teaching in order to be more effective in those materials that they included. As a junior engineering professor at Multiversity put it, "I think it is much better for them to marinate in the core topics rather than to dip them into the sauce and take them out." Somewhat less poetically, another professor explained:

I have systematically reduced the amount of material in the five years I've been here. I cover about 30% less. [I'd] Rather ... have them know five important things well, than seven [not well]. I made the decision that I would put quality over quantity.

A mid-career woman at Multiversity said that after getting tenure she decided to identify some textbook chapter(s) that could be omitted, in order to have enough time to have students actually learn the remaining material. She was surprised to find in some courses she covered almost as much as previously. Having laid the foundations more slowly and successfully she then moved more quickly than formerly. An Associate Professor in another Multiversity department said about the tension between the amount of content and the need to have students master it: "It's a big problem, a very big problem....I keep getting rid of things that may be important from a theoretical point of view so we can get to the practical. [The program] should be five years full-time instead it's four years part-time [because of non-major requirements]."

Deciding to cut back on coverage in order to enhance effective learning is a delicate matter, because many engineering professors are teaching in a comparatively tightly-coupled sequence with colleagues, and changes in coverage will likely become public knowledge. In addition to insuring that the prerequisite material is included, the faculty who want to cut out some content may be concerned that they will be accused of lowering standards, or being "coddlers."

Reference to their students' future jobs was common, and often was used to explain why one teaching technique rather than another was adopted. For example, when I questioned if students' test performance might be affected by the stress of time limits, faculty often referred to the work of engineers. Some tried to minimize or eliminate this factor in student testing; others took it is an immutable aspect of their classes, citing obstacles to change including the institution's scheduling practices, or the increased chances of successful cheating with more innovative test administration arrangements. Interestingly, those on both sides of this issue explained their positions by referring to their conception of the typical work requirements of engineers.

Similarly, when discussing the use of groups in their courses faculty referred to the work arrangements in engineering workplaces. Using groups can be challenging; there are issues of the size, how to compose the membership, how to achieve equity among the students in workload and in grading. Despite trying different arrangements over time, professors agreed that no arrangement solves or completely avoids problems in the use of groups. Indeed, if it were not for the expense of equipment (precluding a set-up for each student), there might be less use of groups in engineering courses. When faculty discussed how they dealt with the various issues, they often referred to practices in engineering workplaces to justify their decisions. While changing practices was sometimes rejected because it would presumably weaken students' training, faculty occasionally suggested ways in which more progressive practices would improve the educational experience. Some with job security felt free to express their views but were pessimistic about change in their institution or in engineering education. Junior faculty who thought the institution needed changing for the most part kept a low profile with such views. A few, with outstanding records of both teaching and scholarship, felt comfortable about

speaking up. In departments having a critical mass of newer faculty from educationally progressive programs, a push for change came from the bottom up. Several junior faculty contrasted their experiences in graduate schools in the western U.S. (which they believed to be regionally typical) and practices in the Northeast.

Assumptions about Students from Nontraditional Groups

Presuppositions about categories of students are likely to affect faculty behavior toward individuals in those categories. For example, if a professor assumes Asian American women are typically silent in class, he may not notice the slight gesture a student uses to indicate she wants to participate. Students who are repeatedly ignored often stop trying to participate.

Given their obligation to produce only competent engineers, faculty assumptions about nontraditional students are crucial to faculty willingness to change curricula or pedagogy. Generally, faculty members were uncomfortable when asked about differences among categories of students. Few seemed conversant with language that can describe differences without implying a biological determinism. Most faculty take the global position that no one's potential to become an engineer is biologically precluded by sex and/or ethnicity. Indeed, several faculty accompanied remarks about Black students' high attrition with observation of performance differences between students from the United States and foreign or immigrant Black students. Beyond this consensus, however, instructors ranged from those with detailed accounts and complex reflections about individual students of color, to instructors who shut down the topic in a way that suggested they had not reflected on the experiences of nontraditional students.

A few who spoke about difference explicitly were trained outside the U.S., in cultures with a more proportional gender representation in science, mathematics, and engineering. They saw differences in students' behavior as explicitly cultural products.

Some faculty were attuned to the needs of some category of nontraditional students but impervious to the needs of others. Thus, some white men (often husbands, brothers, and fathers of professional or professionally oriented women) viewed some extra support for white women as legitimate: it helps them achieve their presumably equal potential. For ethnic minorities whose potential was not presumed equal, or whose "attitude" was believed to be maladaptive, the rhetorical defense against attending to differences remained.

If different student styles respond best to different teaching approaches¹³, faculty inattentiveness to student variations is an obstacle to improving retention. Some faculty defended their inattentiveness to variation by calling it coddling and claiming it would lower the quality of education. Most faculty focused on the possibility of someone graduating who is below standard. Only rarely did a faculty member express concern about losing someone who would have been a good engineer.

Faculty varied greatly in their expectations of the faculty effort required for students from traditionally underrepresented groups to succeed. These expectations are based on ideas of what

new students are like. Thus, several professors (representing every institution in the sample) made a distinction between African Americans and Black students from other countries. This was sometimes followed by a comment about the inappropriateness of expecting the institution to make up for the first eighteen years of students' lives. While these comments distanced the speaker from biological determinism, there was instead a strong claim that the injuries of growing up in difficult economic and social circumstances have put successful performance in engineering school out of reach. (The conflation of race and class in this context went unacknowledged.) In contrast, several professors saw the performance differences between economically disadvantaged U.S. black students and immigrant Blacks as a challenge to be met rather than avoided by their institution (but not always themselves).

Some faculty felt obligated to take a non-blind approach to fair equality of opportunity, given students' gaps resulting from inequitable experiences (such as quality of secondary schooling). Others took a procedural approach, treating all students identically (relying on non-faculty support to deal with student needs). Several were articulate about the conflict between taking a differentiated approach in order to provide *fair* equality of opportunity, and the meritocratic values of our society. In popular terms, faculty realized that helping to "level the playing field" for nontraditional students may be construed as undoing the level playing field, from the perspective of traditional students.

Faculty were sometimes unaware of ways they aggravated underrepresented group members' feeling of being outsiders. Professors might take for granted student background experiences that were not actually shared (e.g., with something as simple as a sports analogy). Many students (including white men) do not, in fact, recognize terms which professors assume to be commonly known. In addition to adding to a student's sense of marginality, use of such terms interferes with student's following the point that the terms were meant to help elucidate.

Although the engineering faculty disagreed about the relative importance of obstacles to equality of opportunity for some groups, most agreed that systemic obstacles play a role (even if only prior to college). However, most did not see this improvement of this situation as part of their obligations as a professor. Instead, they emphasized the serious obligation to insure that only competent individuals were graduated. To the extent that respondents embraced the obligation to provide fair equality of opportunity, they generally situated that obligation elsewhere in the university, but not in the engineering program itself. Whether or not faculty articulate their value judgments about fair equality of opportunity, faculty responsibility, and faculty interests, these values influence individual decisions about the faculty member's daily professional life as a teacher, advisor, and participant in programmatic decision making.

One or more of the following beliefs, rarely stated so bluntly, appeared in many interviews. Some faculty who raised them critically felt that they were in the minority in their views within their department or institution, while others contrasted their progressive local environment to the larger professional culture. Some junior faculty compared their progressive graduate school climate to the more traditional environment of their first faculty appointment.

Some women excel in engineering - thus there is no need to change practices to improve retention of women.

It is the teacher's job to insure a level playing field now, not to figure out how to compensate for inequities students may have previously experienced.

Immigrant students of color are better students than their U.S. counterparts - thus culture and/or poor schools rather than biology or characteristics of the engineering school itself explains under-representation of people of color in engineering.

Our resources should not have to be directed to students who have not been adequately prepared for our program (and perhaps there is no way to remediate their problems, anyway).

How can we explain the persistence of these beliefs, which undermine faculty commitment to change? Is it because of a lack of information about their inaccuracy? Is their problematic logic simply unstated and unexamined? Do they reflect a strong disciplinary world-view? Finally, why do those faculty with more modern views perceive more traditional views as dominant? The crux of an explanation rests on a common set of organizational features of engineering programs, to which I now turn.

Salient Organizational Features

Faculty practice as undergraduate educators is influenced by national and local factors as well as individual experiences. Most obviously, faculty consider the relative importance of teaching, publishing, and garnering external funding in hiring, promotion, and tenure decisions.¹⁴ Where graduate programs exist teaching obligations may be defined in terms of masters and doctoral level students - more obviously compatible with one's research. If the institution invites or allows this broader definition for the assessment of teaching, faculty are less likely to feel pressure to make undergraduate teaching a high priority. The realities of daily life for engineering faculty, like liberal arts faculty, do not lend themselves to a radical reconstruction of their educational activities.

External Influences on the Institution

Changing ABET requirements press engineering programs to incorporate more non-technical courses (e.g., ethics; social sciences; writing). These requirements may not be fully implemented, but they do influence the shape of curricula, and reduce the freedom of a program or institution's faculty. Although many faculty believe that formalizing a five year bachelor's program would best serve their students, few institutions will take the risk of losing enrollment by acknowledging that successful completion of the bachelors requirements often takes five years. With a serious decrease in high school students' interest in engineering, consideration of curricular innovation is made in a context of competition for students with other institutions and other fields of study. This concern with marketing has also led to an increased focus on high quality undergraduate teaching and student services.

Engineering schools are also influenced by the industries and the firms that hire their graduates. Many employers are satisfied with the production of engineers who have survived a

“boot camp” socialization experience. Diversifying the profession and changing the curriculum may make engineers less “manageable.” This conservatism may be presumed (and respected) by educators, or actually be more explicitly voiced via employer-representatives on boards of trustees and other governing or advisory liaisons between the corporate and educational spheres. One junior woman faculty member told me she had mixed feelings about encouraging women students to continue in engineering because of what she perceived as the overwhelming unfriendliness of the profession itself to women. She anticipated leaving the profession within five years of our conversation.

The College or University Level

Institutions vary; for example, colleges traditionally are more likely than universities to emphasize the undergraduate experience.³ Some recognize effective teaching beyond an annual Outstanding Teacher award. In contrast, many departments and institutions often reward bad teachers by reducing their teaching load, to minimize their harm. At Multiversity, a senior professor described a strategy for handling a tenured colleague regarded as a poor teacher: “We might give a bad teacher a big course. We say, ‘Let’s document this’ and give him a big course. Students aren’t *damaged* by it, [although] the course wasn’t done as well as it should have been.” While the professor was considered bad enough to warrant the creation of an official record, his colleague did not think him bad enough to harm students taking his course.

Some graduate institutions are now pushing to improve the undergraduate academic experience. Faculty at four year colleges and at universities have been devoting increasing time to teaching.²¹ How do institutions juggle their interest in undergraduates with expectations of externally supported research, even as funding opportunities decline? These trends are leading in some places to structural changes (e.g., serious weighing of individual and programmatic performance with undergraduates in decisions of resource allocation; development of specialized positions such as a full-time undergraduate departmental advisor). However, some faculty viewed such changes as passing fashions rather than part of long-term trends. Whether they agreed or not with the changes, they were reluctant to change the allocation of their own professional resources based on leaders’ symbolic endorsement of improved undergraduate education.

We know that institutions are more successful at changing if their top administrators clearly and consistently support changes both materially and symbolically. This may include provision of high-quality instructional training and faculty development facilities, or released time for those central to a thorough going curricular revision. If institutional leaders make it clear that nontraditional students should not face a chilly climate, as a lower level woman administrator at Tech put it, even “the tenured ones have to change behavior, regardless of attitude.”

However, a decades-long reliance on its engineering departments to bring in external funding may undermine an institution’s call for improved service to undergraduates.¹¹ As a senior, liberal arts woman faculty member at Tech remarked about supporting women in engineering, “The president has been publicly supportive... They have not been forthcoming with bucks.” Many faculty were skeptical about administrative sincerity in the absence of material

support for curricular and pedagogical change, and in the face of unchanging expectations of high research productivity. Academic advising exemplifies faculty concerns. Common complaints about academic advising included: its labor intensity, its limits (e.g., in situations with family crisis), and the need for some familiarity with "bureaucratic" policies and procedures. The conscientious performance of advising duties is not relevant to personnel decisions, but takes faculty away from activities that are.

Faculty have been trained to do scholarship; training for teaching is scarcer. Because a relatively low proportion of engineering doctoral students will take teaching jobs, training for teaching continues in most programs to be a low institutional priority. Thus graduate students may be used as teaching assistants without a serious effort to train them to teach.

In contrast to their own decision making about changing course content, professors were critical of administrative pressures to allow under-qualified students to enter and perhaps to complete an engineering program. Friendly, Multiversity, and Tech each suffered from the national decline in engineering enrollments, and professors at each referred to administrative pressure to admit students who were either under-prepared or who even lacked the basic capacities to become successful students. Under-preparation was sometimes resented for requiring remediation using scarce institutional resources. More often, faculty voiced concern that their institution did not offer sufficient support services, and students were seen as sometimes lacking the time or the commitment to take advantage of those that were made available.

Some faculty reported being pressured to retain poorly performing students. A mid-career, Latin American immigrant at Multiversity reflected on the situation of students of color from lower quality high schools: "There is an effort to bring them up to speed but also a tendency to lower the barrier which only makes it worse because they aren't building the foundation." This professor strongly supported efforts to integrate the engineering profession, but did not want students to pass unless they had mastered essential materials. Institutional failure to provide adequate remediation, in his view, threatened this goal.

Similarly, the admission of students from other countries with substandard English language skills was an object of concern and complaint, particularly from faculty at Tech, with its large immigrant and foreign student population. Many people with student visas are determined to stay in school and to complete a degree in order to gain immigrant status; this was a source of particularly strong pressure, as reported by faculty. If one insisted on grading according to one's standards (an ethical issue, as one respondent explicitly put it) one would probably receive lower student evaluations, and disgruntled students might complain to department administrators.

In contrast, at Multiversity several faculty described the traditional arrangement of admitting more students than were expected to remain, in order to have sufficient enrollments in freshman and sophomore courses to satisfy administrative pressures. Thus, it was normative to have high attrition because not all those who initially attended were actually expected to persist.

If a large proportion of students did poorly in the early, large courses, it was seen as reasonable given admissions practices rather than an indicator that the courses needed changing. Faculty did not agree in their view of the acceptability of this practice, however. While some underachieving students could be “brought up to speed” and others were successfully discouraged, some would persist until their grades qualify them to graduate, even without mastering the materials.

Faculty Perception of Personnel Practices

While junior faculty (consistent with a national trend) reported a strong commitment to teaching, they saw time devoted to teaching as undermining chances for career success; middle level faculty also saw scholarship and research achievements continuing to overshadow teaching records for personnel decision-makers. This view of the expectations was shared by more senior colleagues and those in service departments. Simply put, competent undergraduate teaching is now required, but excellence in teaching does not substitute for a strong research record in personnel decisions. In a multi-disciplinary study, Milem et al. found that while faculty time spent in teaching related activities had indeed risen; time spent on scholarship had not declined to compensate for this increased work load.²¹

Many faculty were skeptical about administrative sincerity in the absence of material support for curricular and pedagogical change, and in the face of unchanging expectations of high research productivity. Academic advising exemplified faculty concerns. Common complaints about academic advising included: its labor intensity, its limits (e.g., in situations with family crisis), and the need for some familiarity with "bureaucratic" policies and procedures. The conscientious performance of advising duties was viewed as irrelevant to personnel decisions while taking faculty away from activities that mattered.

By virtue of their student experience in departments with doctoral programs, new professors are likely to be acutely sensitive to a research emphasis. Whether myths or accurate perceptions, beliefs about personnel practices have a major impact on individual faculty decisions about their professional lives. Even faculty who view them as locally inaccurate may be concerned about their salience to future administrators or at institutions to which they might want to move. Widely-held perceptions included:

If decision makers want to make a negative decision, they will point to less-than-excellent teaching.

If they want to make a positive decision, only truly horrendous undergraduate teaching will interfere.

Teaching or advising related articles, grants, and awards count toward career success little or not at all.

Undergraduate advising doesn't count.

Where expectations for teaching rise, they are not offset by a lowering of other expectations for faculty performance.

Where expectations for publications and grants rise, those for teaching and advising are unchanged.

Department: Culture and Structure as Everyday Reality

Except in very small institutions, departments are the key unit of organizational culture and practice; this is generally true throughout American academia.^{3,32} It is the faculty member's daily professional world. Departmental colleagues, more than any other group, are likely to influence faculty perceptions of their ethical obligations.¹⁸ It is where most conversation about teaching issues takes place. In graduate programs, it is usually the place where actual standards and processes for training teaching assistants are enacted.

Although the perceptions of personnel practices described above are widespread, the department can influence that perception. It is the first level of faculty personnel decisions, and a departmental administrator is usually the first step in student complaints, and the first site for reviewing the results of standardized course evaluations. Individual departments are critical in creating and maintaining a positive climate for teaching and advising, as well as in allocating rewards to faculty.³⁵ Conversely, the department's lack of concern with teaching issues sets a tone for new members. Thus, a new, mid-career woman who encountered major differences between the largely immigrant students in her new job and the largely U.S. born white students in her previous had received no training for dealing with the ethnic mix:

...the department I'm in, they could care less about how you interact with the students.... you just come in and fend for yourself. [As an example, she had asked a few colleagues about how to effectively teach a class that met only once a week (for three hours)]...they thought it was a bizarre thing to be worried about.

Departments vary in the metaphors, like "boot camp," that members use to describe their own and others' prescriptions or proscriptions for engineering education. The assumption that attrition indicates rigor was most common in departments with high attrition rates (and those with low enrollments of students from underrepresented groups); they suspected that departments with lower attrition apply lower standards or offer a less intellectually challenging program.

Departments also vary in their age, sex, and racial-ethnic composition. One High Power professor said every tenured male in her department had a wife who did not work outside the home. Whether or not this was accurate, it reflected her sense of their lack of understanding of alternative views of women's lives, and the seriousness of women's commitment to engineering. She also brought this up to argue that her colleagues could not begin to understand the work-family balancing that she had to do. Her department had very few non-tenured faculty, making her perception of the generation gap much more significant. Likewise, in other departments and institutions I spoke with junior men with professional wives and demands for family work who felt that their older colleagues "just didn't get it."

Departmental loyalties (for example, concern about resource reallocation) clearly influence faculty perspectives on curricular change. In addition to concerns about the intellectual

integrity of changes, organizational and departmental loyalties (for example, concern about resource reallocation) clearly influence faculty perspectives on curricular change. Serious competition for chunks of the student's academic program, and inter-departmental competition for student majors may discourage a department from making changes. At one engineering school, this was illustrated in efforts to increase composition requirements. Knowing it will open a "can of worms" may motivate faculty and administrators to postpone curricular review.

Policies set at higher levels in the institution are implemented variously by departments. A faculty member's approach to undergraduate education is influenced by and evaluated with reference to his or her department. Thus, a relatively innovative member of a traditional department may be quite unaware of additional innovations that are commonplace in another department. In some departments, faculty who devoted time to undergraduate teaching or curricular innovation were suspected of inadequate involvement in research. This view often discouraged public discussion about teaching by junior faculty, who did perceive it to be a powerful influence on faculty. Some senior faculty did not realize the seriousness with which junior colleagues heard such comments.

As a central administrator (white woman) at Tech observed when asked about views of women engineers among immigrant faculty, the new department member will notice what is going on within his department, because that is who he associates with. He's "gonna check out what's the mode here, quietly observe." She emphasized the importance of "getting at the tenured faculty and trying to change that because the new ones take it from the existing climate."

What seem to be local departmental differences in group graduation rates are often related to disciplinary patterns (e.g., mechanical engineering nationally has a lower-than-average proportion of women). Whether intrinsic or due to variations in history and traditions, disciplinary influences must be considered.¹ They may be used by faculty to justify those varied enrollment patterns (e.g., the argument that women are more comfortable with chemistry than with physics; that women are concerned about getting dirty - associating mechanical engineering with the work of mechanics).

Finally, departments vary in the proportions of their faculty from traditionally underrepresented groups. At the same institution, the demographic differences found nationally among disciplines are likely to be found in the faculty itself. But there are also historical circumstances that contribute to variations among institutions within a discipline. Once a department has successfully recruited a threshold number of faculty from a non-traditional group, it is likely to keep that profile growing. For example, the Department of Mechanical Engineering at the University of Texas at Austin (not in this study) has five faculty women. While it is a large department, this number compares to many doctoral granting programs without a single woman on the faculty in Mechanical Engineering. Clearly, they will be able to attract more women who consider the number already there a positive quality in itself, as well as an indicator of a female-friendly group over all.

A mid-career woman in civil engineering described herself as not fitting students' expectations. When asked to explain, she replied:

I'm not a man, for number one. I tend to be more progressive, more liberal than most engineers, I don't use my notes over and over again in teaching, seems to happen more here than in [Midwestern institution where she had worked]... can't get last year's exam and do well this year, which they can in a lot of classes."

Because members of underrepresented groups are usually called on disproportionately for committee service and informal advising of students from the same underrepresented group, the departmental demography is significant. The fewer nontraditional faculty, the greater the burden on each individual for committee service. The only woman in her department at High Power told me she was the poster child for women in engineering: she felt like she was tapped to make an appearance whenever there was a public event requiring someone from her department. Where there are few nontraditional faculty but a higher proportion of students from those nontrad groups, the burden is also heavier. Because neither service on committees nor advising are significant factors in personnel decisions, these burdens undermine professional success.

Individual Variation

The monolithic view of engineering faculty (prevalent outside the field) overlooks individual variation as well as change experienced by faculty as they move through their careers.^{23,25,6} Obvious but not simple differences in reflexivity about teaching and curricula emerge related to people's race/ethnicity, gender, family and parental statuses, cohort, and age.¹⁹

A developmental view of engineering faculty directs our attention to life experiences affecting individual professors' values and beliefs about their work. Any faculty member may discover a renewed interest in teaching's challenges. A new perspective on undergraduate education often develops as one's child approaches and attends college. For example, several professors reported that their child's educational experiences had led them to question their own assumption that a professor should not stop to ask questions to explore the effectiveness of the teaching thus far (because of the risk of omitting some later topics). As Tang has pointed out, gender differences in job performance may be too quickly attributed to gender differences in personality.³¹ Rather, they may result from the individual's treatment, including subtle sexism and greater social isolation.

Alternatively, faculty from nontraditional groups may be part of networks outside their department and institution, enhancing their professional development, and potentially providing alternative cultural messages about pedagogy, curriculum, and/or the role of teaching in one's career. Thus, there may be a critical mass developing for making changes in engineering education.

This research revealed a wide variety of faculty stances toward engineering education and change. At one extreme, faculty were happy with traditional arrangements, and satisfied that these arrangements were enough to satisfy students. At another extreme, some faculty perceived their environment as too traditional, having a negative impact on students; but believed that the established views were too firmly held for change to occur. Some faculty spoke of change positively, but had a minimal conception of what change might entail, and were unaware of or dismissive of serious extra-departmental and extra-institutional trends pushing for significant change. Some senior faculty were disappointed with how little change has occurred in their professional setting, and have worked within what they perceived as a narrow area of influence

to support change. Finally, some faculty worked in departments with progressive colleagues collectively working for change in curriculum and pedagogy. The methodology does not permit an estimate of the relative frequencies of these stances, but almost ten years after the completion of interviewing, each stance is familiar to engineering education researchers. The degree to which individual faculty have shifted from one stance to another, or that exiting faculty have been replaced with newcomers having similar or different perspectives is unknown, but undoubtedly the range of stances has survived.

Future Trends

As I conducted the research, and as I have reported on it, I have encountered some administrators who believe that the culture described above has become a thing of the past. However, it is increasingly accepted that institutional change is essential to long term integration of engineering.^{26,22} It is often only relatively overt features of the “chilly climate” that have diminished or disappeared (e.g., inserting a “centerfold” slide in the midst of a slide-based lecture for computer science professionals, which I witnessed in the late 1980s). More subtle features of engineering education that have discouraged nontraditional students have been slower to change.

Although younger faculty replace older cohorts, and new male professors are increasingly likely to have professional wives, the institutional pressures on engineering faculty are unmitigated. If younger, change-oriented professionals are discouraged by a conservative institutional culture, the ranks will be disproportionately filled by relatively conservative younger professionals. Women who move into male-dominated disciplines, such as engineering, may seek alternative career paths if they perceive persistent though subtle sexism. A junior woman faculty member at an institution I visited briefly expressed pessimism about changes in the climate, and questioned whether it would be right for her to encourage women to stay in the engineering program, given her expectations that she herself would leave the profession within the next five years because of the hostile climate she experienced.

When more junior faculty arrive or achieve tenure, there may be more public discussion about ways of teaching and advising undergraduates that shifts the ideology from fearing change as coddling to seeing change as essential for nurturance. The real time required for following up on such an ideological change will depend on local and national trends in the relative power of forces towards faculty “productivity” versus the development of an intellectually effective, warmer classroom climate. But if a department builds in a revolving door (with teaching oriented and nontraditional faculty coming into, and then leaving, junior positions), the apparently integrated faculty will not necessarily change to women-friendlier practices. Significant structural changes will be needed to support the current, exceedingly slow movement away from those aspects of the traditional engineering education culture that undermine integration. Making the structural changes will require the reallocation of campus resources, and will test the seriousness of institutional leaders’ commitment to change.⁷

New and unexpected events can have an impact on institutional willingness or determination to make change. After the attacks of September 11, colleges, universities, and particular academic programs with large numbers of foreign students have been concerned about

serious loss of enrollment. National indicators suggest that other countries are no longer a reliable source of students in U.S. institutions. Because engineering programs have led, nationally, in their proportion of students from Arab and other Muslim countries, these programs are even more likely than other fields to experience enrollment decline. This major and obviously unanticipated change in enrollment projects in engineering may move top administrators to take more seriously the need for resource allocations associated with stronger recruitment and retention of under-represented U.S. high school students.

This paper has described the beliefs and the organizational practices that affect how faculty approach undergraduate responsibilities. If faculty are to make changes in undergraduate teaching, advising, and curriculum development, their leaders will have to address the cultural and organizational features of their institutions that impede such changes, which will be particularly important to the retention of women students. Because institutions of engineering education, and departments within them, vary considerably, the conditions I describe below are not universal. Local campaigns for change should be tailored to local conditions.¹⁷

Examples of important characteristics requiring attention from academic leaders include:

Size of classes: large classes make it hard for a professor to know students and to test directly (and thus adjust) his or her ideas about attrition.

First year curriculum (specifically calculus, physics, and chemistry): engineering faculty may have little or no student contact, to inform their thinking about attrition; they have little evidence to challenge their assumptions about who leaves.

There is often a formally or informally established faculty division of labor, with a small proportion of the faculty viewed as knowledgeable about and involved in pedagogical, curricular, and retention issues. All others need not be concerned with these areas.²⁹

Departments typically vary in the admission, retention, and graduation rates of women and of members of various racial/ethnic groups. Within an institution, the more integrated programs may balance out the less integrated, so the less integrated are not pushed to improve their integration rates as well.

Nontraditional faculty have exceptional duties in undervalued areas (committee work, recruiting, advising or mentoring of nontraditional students).²⁴

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