

Digits of Pi: Barriers and Enablers for Women in Engineering

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In a seminar with faculty colleagues last week, we were discussing the information content of a string of numbers—OK so it was a slow day. The assertion was made that the quantity of information equaled the number of bits in the string, unless you were told that, for example, the string was the digits of Pi. Then the information quantity became essentially one. The additional assertion was made that of course all MIT freshmen knew Pi out to some outrageously large number of digits. I remarked that this seems to me like a “guy” sort of thing and I doubted that the women at MIT knew Pi out to some large number of digits.

This got me thinking whether there are other “guy” sort of things which are totally irrelevant to the contributions that engineers make to our society that never the less operate to keep women out of engineering. These “guy” things may also be real barriers in the minds of some male faculty and these faculty may unconsciously, or even consciously, tell women that women don’t belong in engineering. I have recently visited university campuses where that is still going on.

Let me make a strong statement: if women don’t belong in engineering, then engineering, as a profession is irrelevant to the needs of our society. If engineering doesn’t make welcome space for them and embrace them for their wonderful qualities, then engineering will become marginalized as other fields expand their turf to seek out and make a place for women.

So let me give you Sheila Widnall’s top ten reasons why women are important to the profession of engineering.

10. Women are a major force in our society. They are self conscious about their role and determined to be heard.
9. Women are 50% of the consumers of products in our society and make over 50% of the purchasing decisions.
8. Who today would choose a profession that did not have a significant percentage of women?
7. Women are integrators. They are experts at parallel processing, at handling many things at once.
6. Women are comfortable in fuzzy situations.
5. Women are team builders. They inherently practice what is now understood as an effective management style.

4. Engineering should be/could be the 21st century foundation for all of the professions.
3. Women are a major force in the professions of law, medicine, the media, politics and business.
2. Women are active in technology. Often they have simply by-passed engineering on their way to successful careers in technology.
1. Women are committed to the important values of our times, protecting the environment, product safety, education and have the political skill to be effective in resolving these issues. They will do this with or without engineering. They are going to be a huge force in the solution of human problems.

Trends in our society indicate that we are moving to a service economy. We are moving from the production of hardware to the provisions of total customer solutions. That is we are merging technology and information and increasing the value of both. What role will the engineering profession play in this? One future vision for engineering is to create the linkage of hardware, information and management. It seems to me that women are an essential part of this new imperative for the engineering profession if we are to be central to the solution of human problems. Another possible future is to restrict ourselves to the design of hardware. If we do this, we will be less central to the emerging economy and the needs of our society.

The top ten reasons that women don't go into engineering

10. The image of that guy in high school that all of the teachers encouraged to study engineering
9. Poorly taught freshman physics. Linear thinking.
8. Concerned that they won't get a date to the prom if they get the highest math score.
7. Lack of encouragement from parents and high school teachers
6. Guys who worked on cars and computers or faculty who think they did
5. Lack of encouragement from faculty; survival of the fittest mentality. "I treat everyone badly"; constant use of masculine pronouns describing engineers.
4. Lack of women faculty or obvious mistreatment of women faculty by colleagues and departments
3. Bias in the math SAT's
2. Lack of visible role models and other women students in engineering
1. Lack of connection between engineering and the problems of our society. Lack of understanding what engineers do.

These issues of language and expectations, behavior and self-esteem are still with us. Until we face them squarely, I doubt that women students will feel comfortable in engineering classrooms. No, I'm not talking about off color stories, although I'm sure that that goes on. I am talking about jokes and innuendo that convey a message to women that they're not wanted that they're even invisible. It may be unconscious, and it may come from the least secure of their male classmates or teachers; people whose own social skills or self-esteem is so low and who lack such self-confidence that they grasp for comments that at least put them in the top 50% by putting all of the women in second

place. Also, many men express discomfort at having women “invade” their “space”; they literally don’t know how to behave. When I was a freshman advisor I told my women students that the greatest challenge to their presence at MIT would come from their classmates who want to see themselves in at least the upper 50% of the class.

These attitudes are so fundamental that unless they are questioned people just go about the business of treating women as if they’re invisible. I remember one incredible incident that happened to me. When I was a young assistant professor, I was teaching the graduate course in aerodynamics with a senior colleague. I was to give the first lecture. So I walked into class and proceeded to organize the course, outline the syllabus and give the first introductory lecture. Two new graduate students from Princeton were in the class. One of them knew who I was. The other thought I was Prof. Landahl’s secretary and was very impressed at my ability to give the first lecture. I think you can all see the intellectual disconnect in this example. It never occurred to this student that I might be a professor, although I’m sure I put my name and phone number on the blackboard. So he thought there were two professors and one secretary. I did in fact eventually become a Secretary—but that is another story.

I once got a call from a female faculty colleague at another university. She was having trouble teaching her class in statistics. All of the football players who were taking it were sitting in the back row and generally misbehaving. If she asked me that today I don’t know what I’d say. But what I did say—that worked—was that she should call them in one-by-one and get to know them as individuals. This evidently worked and she sailed on. Today she is an outstanding success. I doubt if many male faculty have had such an experience. But this clearly was a challenge to her or she wouldn’t have called me. I believe that all women faculty have such challenges to their authority in ways that would never happen to a man. Students will call a female professor Mrs. and a male professor Professor. I told one student that if he ever addresses Senator Feinstein as Mrs. Feinstein, he will find himself in the hall. If it is happening to women faculty, I’m sure it is happening to women students, this constant challenge to who they are.

We all have unconscious attitudes that impact our effectiveness as educators and cause us to negatively impact our women students. I remember one incident: I was advising two students on an independent project: a guy and a gal. (The gal was the better student). We were meeting to discuss what needed to be done. I found myself directing my comments to the guy whenever there was discussion about building, about welding or cutting. I caught myself short and consciously began to direct my comments evenly. I went to my departmental colleagues and said: “this is what happened to me. If I’m doing it, you surely are”. Do male faculty welcome the appearance of female students in the classroom? Do these faculty resent having to teach women and feel the department is diminished somehow when women are a significant faction of the students. You might think so when you notice the low percent of engineering women graduate students that results when selection is more clearly controlled by these individual faculty.

And then there is the issue of evaluation and standards. I don't think that we as a profession can just sit by and evaluate women to see if they measure up to our current criteria. We have to reexamine the criteria. As an example: One of my faculty colleagues, whose daughter was applying to MIT—thank God for daughters-, did a study of whether admissions performance measures—primarily the math SAT--actually predicted the academic performance of students, not just as freshman but throughout their undergraduate careers. He did this differentially for men and women and got some surprising and very important results. He found that women outperform their predictions. That is, that women perform better as students than their math SAT scores would predict. The effective predictive gap is about 30 points.

Thus the conditions were set to change admissions criteria for women in a major way. The criteria for math SAT for women was changed to reflect the results of the study. In one year, the percentage of women students in the entering class went from 26 to 38%, And it worked! We have been doing this for close to 20 years now and the women have performed as we expected. Women are now about 50% of the freshman class.

Along the way, we identified some very important critical mass effects for women. Once the percentage of women students in a department rises above say 15%, the academic performance of the women improves. This suggests a link between acceptance and self-esteem and resulting increases in performance. These items are under our control. I am convinced that 50% of performance comes from motivation. An environment that truly welcomes women will see women excel as students and as professional engineers.

At this point, all of our departments have gone critical. Women undergraduates, who are now 41 percent of the MIT undergraduates, outnumber men in three of the five schools and 15 of the 22 undergraduate majors. Women are still outperforming their male counterparts.

At MIT, women are the majority in four of the eight engineering courses: chemical engineering, materials science and engineering, civil and environmental engineering and nuclear engineering. With the possible exception of Smith College, which is starting an engineering program, I have not heard of another engineering department anywhere in which women are a majority of the undergraduate students. In the entire School of Engineering, women are 34% of the undergraduates.

Anyone who has taught in this environment would report that it has improved the educational climate for everyone. We in Aeronautics see it in our ability to teach complex system courses dealing with problems that have no firm boundaries.

Ten top reasons why women are not welcome in engineering

10. We had a women student/faculty member/engineer once and it didn't work out.
9. Women will get married
8. If we hire a woman, the government will take over and restrict our options.

7. If you criticize a woman, she will cry
6. Women can't take a joke
5. Women can't go to offsite locations
4. If we admit more women, they will suffer discrimination in the workplace and will not be able to contribute financially as alumni. —I kid you not: that is an actual quote.
3. There are no women interested in engineering
2. Women make me feel uncomfortable
1. I want to mentor, support, advise, evaluate people who look like me

So how do we increase the number of women students and make our profession a leader in tackling tough societal problems? What do we need?

Let me give you my list of the ten effectors

10. Effective TV and print material for high school and junior high girls about career choices.
9. Engineering courses designed to evoke and reward different learning styles
8. Faculty who realize that having women in the class improves the education for everyone.
7. Mentors who seek out women for encouragement
6. Role models: examples of successful women in a variety of fields who are treated with dignity and respect
5. Appreciation and rewards for diverse problem solving skills
4. Visibility for the accomplishments of engineering that are seen as central to important problems facing our society
3. Internships and other industrial opportunities
2. Reexamination of admission and evaluation criteria
1. Effective and committed leadership from Faculty and senior administration

Technology is becoming increasingly important to our society. There may be an opportunity to engage media opinion makers in communicating opportunities and societal needs to young girls. I don't believe that the engineering profession alone can effectively communicate these messages but in partnership we can be effective. These issues are important for our society as a whole, not just for engineering as a profession.

However, we do have a good bit of housecleaning to do. We must recognize that women are differentially affected by a hostile climate. Treat a male student badly and he will think you're a jerk. Treat a female student badly and she will think you have finally discovered that she doesn't belong in engineering. It's not easy being a pioneer. It's not easy having to prove every day that you belong. It's not easy being invisible or having your ideas credited to someone else.

What I want to see are engineering classrooms full of bright, young, enthusiastic students, both male and female in roughly equal proportions, who are excited about the challenge of applying scientific and engineering principles to the technical problems facing our

society. These women want it all. They want full lives. They want important work. They want satisfying careers. And in demanding this, they will make it better for their male colleagues as well. They will connect with the important issues facing our society. Then I will know that the engineering profession has a future contribution to make to our society.