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Feminist Scholarship Review: Women and Engineering

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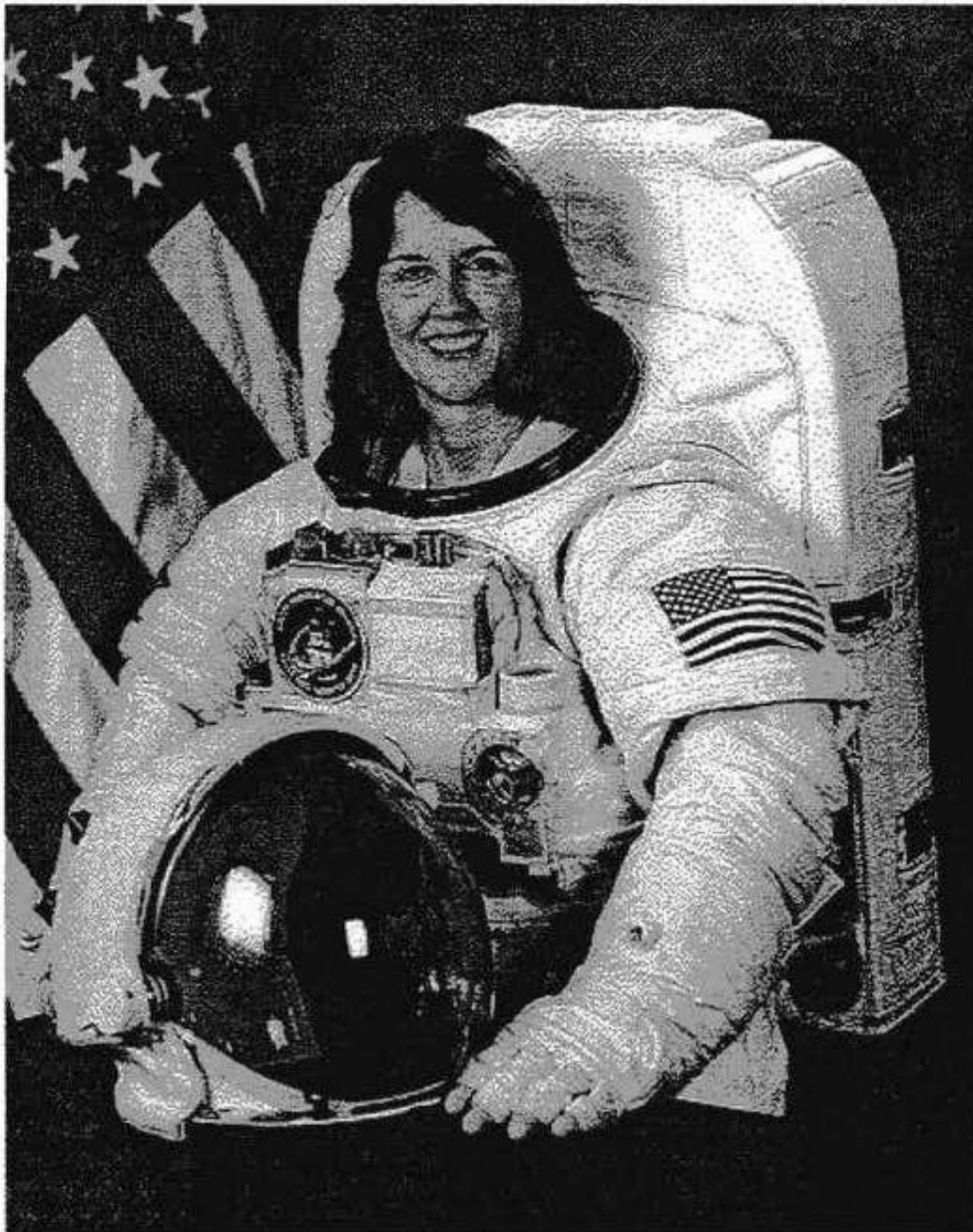
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Feminist Scholarship Review

Women and Engineering

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Feminist Scholarship Review



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To the readers of Feminist Scholarship Review:

As you read the following pages on the topic of women and engineering, you may be struck, as I was, by an important idea that threads itself through many of the articles: the idea of image. Image in all its permutations, from self-image to the image of the individual that others hold. Self image bears indelibly upon self-confidence. The expectation that she can perform and succeed in the many fields of math and science begins very early in a woman's life. The images held by others mold and cast the beliefs of those others. A girl who imagines herself as someone who can "do science" becomes a young woman who *does* "do science." And those others who can envision an engineer equally as a female or as a male will be the relatives and friends of female engineers as well as those who hire, support and retain them. Necessarily, the personal vision broadens to include a culture which produces and (equally) rewards competent, successful engineers, regardless of gender.

The images we hold of ourselves and of others, though, include so much more than the occupation we choose. The talent and potential to be a full person who can do and be many things is what society benefits most from promoting. Teachers and students are mutually engaged in this pursuit to "be all we can be." John Mertens, who has contributed to this issue of FSR, exemplifies this mutual endeavor. Several years ago, I had a prospective engineering student enrolled in one of my writing intensive sections. She may have been working at her math and science identity, but was ignoring the part of her that had the potential to write well. Prof. Mertens was her advisor. I called him with my concerns about this student, and found that he was enthusiastic about talking with her to try to encourage her to put more effort into her writing. His image of the engineering student was generous, broad. He quoted to me a survey he had recently read which revealed that one of the two skills that engineers felt were lacking five to ten years after they received their degrees, was the ability to writing well. Prof. Mertens held an image of this student and, by extension, of all students in this field, as a whole person, as being more than the sum of her training and skills.

The images we hold of ourselves and of each other depend dramatically upon information and discussion. My hope is that this issue of FSR will add positively to our knowledge about women and the field of engineering.

A handwritten signature in cursive script that reads "Deborah Rose O'Neal". The signature is written in black ink and is positioned above the printed name.

Deborah Rose O'Neal

Women In Engineering: Progress, But Still A Need For Change

Women are under-represented in the engineering field, and many studies currently address the topic of recruitment and retention of women in engineering. Over the past several years, interest in this problem has grown, and large corporations and many academic institutions are now working to reverse the trend. Why and how are companies and institutions addressing these issues? Ask these questions and one of the immediate replies is very often given with the expression "affirmative action". Affirmative action is designed to provide opportunities for all qualified individuals by allowing all people to compete equally. However, competing for the job is only a very small part of the battle. Increasing the number of accepted under-represented applicants does not necessarily assure an increase in long term representation. The major problem is retention. Despite the inroads women have made in the field of engineering, retention problems have prevented many organizations from fully utilizing the talents of their female engineers. Much more needs to be done and U.S. corporations are just starting what is, as many see it, some essential change.

Twenty years ago, 0.8% of engineering graduates earning a bachelor's degree were women; in 1990, 15.4% of engineering graduates were women¹. These statistics suggest that while the representation of women as engineers in the workplace has been low, their numbers have increased significantly in recent years. So why is there continued concern? Demographic studies indicate that the number of prospective engineering students to be drawn from traditional backgrounds will decrease in the years ahead. Today women and ethnic minorities together make up about 25% of the engineering bachelor's degrees awarded. According to a recent estimate, within 40 years the proportion of this group must increase to 75% just to maintain the current number of engineers graduating with engineering degrees². It is obvious why this might be important to an engineering school where students are their bread and butter but, how does this impact corporate America? Further studies have shown that an organization's ability to successfully compete in the highly competitive global marketplace of the 1990s will depend on how well it uses its human resources, which includes maximizing the full potential of its female and minority engineers [e.g., 1]. So the motivating factor is, not surprisingly, *money*.

Retention and its impact on corporate America are addressed in the January 1997 issue of the Journal of Management in Engineering. The authors identify workplace barriers that are described "as those actual or perceived activities that occur in organizations that may limit the professional careers of women

engineers, or cause them to experience job related psychological stress.” These barriers are distinguished as professional (e.g., lack of advancement, mentoring, and training opportunities) and psychological (e.g., issues related to balancing work/family expectations and sexual discrimination/harassment). The authors suggest that a change in the “corporate culture” will be necessary to remove these barriers. It is also argued that the removal of these barriers will result in the ultimate gain of a competitive edge in today’s global markets¹.

That is easier said than done. We are, once again, presented with the much over used (and abused) solution of changing *the culture*. What do we really mean? Can rules and regulations really change how people think and act? To some extent, we can control the actions of individuals but, we cannot change their beliefs. That is what really needs to happen. If women are going to become truly integrated and fully utilized in the engineering workplace, the majority must truly believe that it is a worthwhile option (including women themselves). For example, men and women can, if they choose, share child care responsibilities or, if a woman (or man) does decide to remain the primary child care provider, she (or he) can still make a very significant contribution as an engineer. I often wonder why women are not under-represented in other fields. Women do in fact have the slight majority in, for example, the life sciences. The explanation given by one author for this majority is that the “cultural deterrents are fewer.”³

To improve representation in engineering, it is once again implied, that *cultural change* is necessary. I feel that time and patience may be the deciding factor. Institutional change is essential but, only with time and personal experience will people truly begin to understand and accept these changes. Where my grandfather might not have understood and believed that a woman could be an engineer *and a mother*, my children surely will. Does that mean that we should sit back and wait for time to pass and for people to change? That is definitely not the answer. We should look to where the problem really starts. I have talked a great deal about the retention problem in corporate America but, all engineers have one thing in common: an engineering education. The retention problem is also very real in the academic world. Isn’t it possible that an engineering education actually conveys more (or less) than just the necessary engineering skills? Many of the most talented female students that are recruited to study engineering do not successfully obtain an engineering degree³. Those that are “successful” in obtaining the degree often leave feeling less confident than their male counterparts. This quality of diminished confidence continues and is often linked with problems of retention for women later in their careers⁴.

The reasons for the loss of high ability women from engineering majors is not well understood. Studies have consistently revealed an early loss of confidence in the ability to “do science” for these students. This loss of

confidence is due to “a misfit between the learned expectations of women entering college mathematics and science classes, and those of faculty and male peers, about the purpose and nature of the undergraduate experience in these majors.”³ The result is that these women judge themselves very harshly. Many enter the major because they are “good in math and science” and they are advised that it is “the major for them”. They leave the major because it is not what they expected it to be, and often, because they have not performed the way that they expected. However, statistics show that these women are performing just as well, if not better, than their male colleagues³. So why do they leave? Interviews with women engineering students reveal difficulties and dissatisfactions with their engineering programs. It has been proposed that better advising, both at the high school, and college level is needed to address these problems⁴.

Young girls must be better educated about what an engineer actually does. Exposure to engineering role models and real life engineering experiences allow these students to make educated decisions about career options. A strong advising program that is introduced to students when they first enter engineering studies is essential. One study indicates that this program should include advising that: (a) provides extensive information about all engineering programs and in which student and advisor seek to match the student's interests and skills with an appropriate engineering specialty; (b) shows concern for the student as an individual, providing encouragement and support throughout her program; (c) provides regular opportunities for an advisor to discuss with the student her performance and to solicit her response to her studies; (d) assists the student in relating the importance of academic work to her professional interests; and (e) includes discussions of options for professional practice, help in identifying suitable work, and guidance in how to secure a first professional position.⁴ Most participants of this study indicated a reluctance to initiate discussions with their advisors to discuss their concerns. The initiation of these discussions by advisors is, therefore, essential since “the lack of evidence of personal concern from faculty or administrators contributed significantly to women's sense of isolation and marginal status as engineering students.”⁴

If this country is going to address the problem of under-representation in engineering (with some lasting effects) the effort must start early. The education of engineers must be reconsidered. The educational change, however, can not start and must not stop there. The public must also realize the importance of an effective engineering workforce in determining the quality of our future. To make this workforce truly competitive all resources must be utilized effectively. This will require some real change, not only in how people act, but also in what they truly believe.

---Christine Broadbridge

1. M. Maskell-Pretz and W. E. Hopkins, "Women in Engineering: Toward a Barrier-Free Work Environment," Journal of Management in Engineering, (January/February, 1997), p. 32.
2. T. A. Bickart, "Gateway to Pluralism: Recruitment and Retention," Engineering Education, (May/June, 1991), p. 419.
3. E. Seymour, "The Loss of Women from Science, Mathematics, and Engineering Undergraduate Majors: An Explanatory Account", Science Education, 79(4), 437-473(1995).
4. V. Anderson, "Identifying Special Advising Needs of Women Engineering Students", Journal of College Student Development, (July/August, 1995), p.322.

Managing Gender in the Workplace: Reflections of an Engineer

What is it like to be a woman in engineering? Well, when I started at a large company over twelve years ago, many people knew my name before I ever got around to meeting them. The phrase "who's the new girl?" spreads quickly. I knew I was one of few female engineers when I read group memos referring to all of us with some form of "he" or "him." One poster I saw encouraged employees to bring their wives to a company technical presentation. I said, "but I don't have a wife!"

Coming from Trinity College and an engineering class of approximately twenty, to a company of over twelve thousand people was definitely culture shock. Luckily, my basic instincts, such as treating others as I would expect to be treated, helped me create a good foundation of working relationships. I learned early on that being a woman in a predominantly male profession was going to be a challenge. I knew I could not expect everyone to understand the presence of women in the engineering department, a department with over twelve hundred engineers.

I loved my job from the onset and accepted the fact that I was on a mission to educate anyone who presented me with an awkward situation, especially as a result of my gender. For example, there was an older gentleman who used to whistle at me in the office whenever he greeted me. I had a great respect for this man and his engineering expertise, but this whistling drove me crazy! I finally gathered up enough courage to privately mention to him that the whistling really bothered me and that I wished he would stop. He didn't realize it bothered me and was very understanding. He never whistled at me again.

I quickly had to get used to the fact that wherever I went at work, many eyes followed me. I know those eyes were there because I would catch glimpses behind me in the reflection of a glass door or a computer screen. Also, if I walked with a co-worker, many times they would comment on the attention which followed me. Now being very visible can be a good thing, until make a move you don't want the rest of the company to see.

One of the most intimidating areas I would walk was down our production line. This is a long wide aisle which is bordered by men (99%+) riveting, caulking, and assembling. The line starts with shells of helicopters on either side of the aisle. As you move down the aisle, the helicopters progressively evolve from station to station until completed aircraft are ready to roll into the hangar in preparation for their first flights. If a woman walked down the production line, what a noisy racket would ensue! People whistling and shouting hello and blowing their air guns. I applauded one clever fellow who played a wonderful rendition of the Star Spangled Banner. I knew many women who would not step foot on the production line. Other women would walk with their noses in the air, without acknowledging anyone's greeting. These women got hassled the most.

Observing the social dynamics of my work environment became a daily adventure. I found that the more I talked with people and got to know them and they got to know me, the more comfortable I felt. Most of the time workers found it a challenge just to get you to say hi, and I was already doing that!

The next step was to get people to use my name instead of "babe" or some variation thereof. All I would say to them was, "the name's Sue or Susan, thanks," smile, and walk away. I would not respond to someone unless they used my name. This exercise worked. I didn't scold anyone or embarrass them in public; I just politely let them know where I stood.

One day an incident occurred as I was walking past my desk. One of my younger colleagues whacked me on the derrière with his hand. Even though I know he thought this was a playful show of team camaraderie, I was put on the spot and had to do something, especially in front of the other guys. I grabbed the fellow by the chin, propped him up against the wall and politely told him that this is something you don't do in the workplace. He never did do that again.

Please note, I do not wish to paint a negative picture for prospective women engineers. The work environment has improved in many ways since the incidents I've related. Rules are strict in terms of how employees treat one another and actions to the contrary are not tolerated. If I had it to do over again I would still become an engineer. I think the engineering profession has gotten a bad rap and we desperately need better public relations. Engineering offers such exciting opportunities for women and men, but so often these opportunities are not communicated.

As engineers, we are problem solvers, technical detectives trying to improve the world around us. I believe I was the 13th woman to graduate from Trinity College, but I don't consider the number unlucky. To love your work is a great thing.

--Susan Thomas '84

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--- Pat Bunker

Information and Opinion: The Gender Gap in Engineering Education

A continuing challenge facing engineering education is the under representation of women in the field. While the percentage of bachelor's degrees in engineering earned by women has been steadily increasing (see below), it still lags far behind other sciences such as biology and chemistry. Why?

Percentage of Bachelor's Degrees in Engineering Earned by Women

1950	1960	1970	1980	1990	1994
0.2%	0.5%	1.0%	9.7%	15.4%	20%*

(Source: Engineering Manpower Commission of the American Association of Engineering Societies, 1990.
*Civil Engineering, August 1994)

Engineering should be an attractive career for women. Despite the fact that most women engineers are relative newcomers to the field (see above), engineering is the field of study with the second highest median pay for women:

Pharmacy	\$47,567
Engineering	\$46,389
Computer/information sciences	\$41,559
Physical Therapy/related services	\$40,491
Nursing	\$40,096

(Source: Bureau of Labor Statistics' Occupational Outlook Quarterly, Summer 1996)

In comparison, the median pay for all engineers was \$56,600 in 1994 (American Association of Engineering Societies, 1995). Much of this discrepancy in median salary between women and men engineers is explained by differences in experience and levels of education, however "glass ceiling" discrimination cannot be ruled out. (A very good article from Quality Digest that discusses factors contributing to gender salary differences in "quality" fields is available on the Web at <http://www.tqm.com/digest/jun/salary.html>).

Starting salaries for women engineers are good as well. Average starting salaries for women engineers are 2-5% higher than those for men with the same level of education (Chemical and Engineering News, October 1996). The table on the next page shows the nationwide average starting salaries for ALL graduates (men and women) with bachelor's degrees in various fields.

Average Starting Salaries for All Men and Women With Bachelor's Degrees in Various Fields

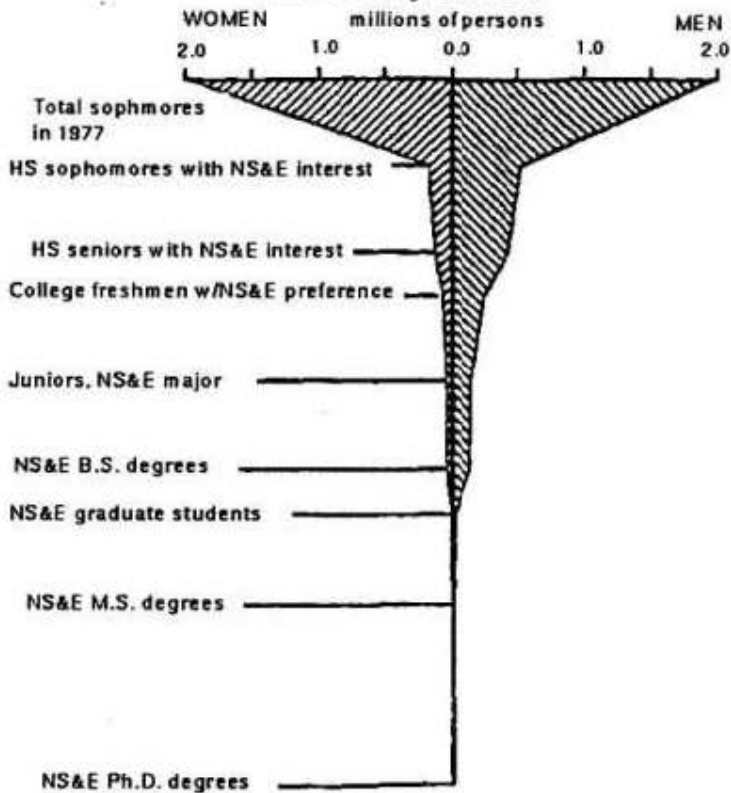
Petroleum Engineering	\$41,050
Chemical Engineering	\$40,341
Mechanical Engineering	\$35,369
Electrical Engineering	\$34,979
Computer Science	\$32,446
Nursing	\$29,868
Civil Engineering	\$29,547
Chemistry	\$28,386
Accounting	\$27,787
General Business Administration	\$23,760
Education	\$22,685

(Source: Collegiate Employment Research Institute, 1996.)

One reason engineering may not be recruiting women students as successfully as other sciences could be that it is still a male dominated field in academia, and may not be viewed as being as "friendly" to women as are other sciences. In 1986, only 2% of engineering faculty at research universities were women (Engineering Education, July/August 1989). While this figure is increasing, there are limited numbers of women in the pipeline: in 1994 only one out of eleven Ph.D. graduates in engineering were women. (One out of seven engineering master's degrees go to women.) (Civil Engineering, August 1994). While all of these numbers, 20% (B.S.), 14% (M.S.), 9% (Ph.D.) are steadily increasing, they still illustrate what is termed the "leaky pipeline": at each level of engineering education, women drop out faster than men. Some of the "leaks" at the advanced degree levels may be explained by women being lured out of the education pipeline by affirmative action hiring programs that exist at most large engineering firms, but the more distressing "leaks" occur long before women reach college.

The figure on the next page shows the difference in interest in Natural Science and Engineering between male and female students beginning in the sophomore year of high school. More than five times as many male students than female students show an interest in the sciences in the sophomore year! The figure also shows that after the sophomore year in high school, the male science pipeline leaks faster than the female science pipeline! It is clear that a major step to increasing the fraction of women engineers is to address female student interest in science BEFORE high school.

Persistence of Natural Science & Engineering Interest by Gender



(Source: Task Force on Women, Minorities, and the Handicapped in Science and Technology, Changing America: The New Face of Science and Engineering- Interim Report, Washington, D.C.: The Task Force, 1988.)

A study that won't show up in a literature search for women in engineering may illustrate the biggest hurdle in encouraging female students to pursue science and engineering. The survey, commissioned by the American Association of University Women in 1990 (NY Times, 1991), studied 3,000 children at 36 public schools in 12 communities around the country. When 9 year old boys were asked how often they felt "happy the way I am," 67 percent answered "always". By high school, 46 percent of boys responded the same way. However, 60 percent of 9 year old girls responded "always", and only 29 percent of high school girls responded the same way. These results coincide with anecdotal information I have heard from a number of women public school teachers while serving on the United Connecticut for Women in Science, Engineering, and Mathematics advisory committee:

"One word: Boys. It happens when the girls hit 11 or 12. They become more worried about what the boys think of them than what subjects they take, and they don't want to be 'geeks'."

Why might taking an interest in science affect how boys think of a girl? Here's what one public grade school teacher relayed was the overwhelming result of an in class survey:

Describe a scientist: Many students responded by describing a Caucasian man in a white coat. Describe a woman scientist: Many students responded by describing an old Caucasian woman who had never been married in a white coat.

One helpful step to encouraging girls to develop or retain an interest in the sciences (as well as in all areas of education) may be to turn to single-sex public schools. In a much-publicized case, on August 21, 1996 the New York City Board of Education voted to endorse an all-girls junior high school in an East Harlem community school district, and to later expand it into an all-girls' high school. On September 4, 1996, 50 girls began seventh-grade class at the Young Women's Leadership School, the first single-sex public school in New York City in ten years. The results of this experiment will be watched closely by educators, administrators, and legal experts, as civil rights advocates argue that the school violates federal and city anti-discrimination laws by excluding boys (NY Times articles, 1996). If the school survives legal challenges, I predict that the graduates will have a far lower "leak rate" than the female graduates from neighboring public schools.

--John Mertens

Engineering Stereotypes

Here is a little exercise to get us started.

Picture an typical engineer.

Glasses? Pocket protector? Gauche?

Now have an imaginary conversation with your engineer.

Out of touch with reality? Unable to communicate unless speaking of their computer? In love with their intelligence?

Where do they work?

A dark room with no Windows? Computers everywhere? Reference manuals scattered about?

By the way, what gender is your engineer?

Okay, you get the point - engineering, and engineers, are surrounded by stereotypes. It would be incorrect to say that these generalizations are unwarranted, but as with any stereotype it would be unfair to start pinning on labels. I propose to explain why engineers have acquired such a powerful image, how they are breaking out of these restricting molds, and the role that women have in this movement.

If questioned, many engineers will react very defensively toward the stereotype above. This leads me to believe that we, as a group of professionals, are displeased with the way society views us. So why don't we just change a little? Maybe read the newspaper, go to the gym, and replace our glasses with contacts. Unfortunately, it is not that easy. I believe the root of our problem is just the opposite of what most people think it is. An example: When I tell people I am an engineer they seem to believe that I am engaged in some mysterious, complex realm of mental gymnastics. Engineers need simplicity! - the real world is too complicated and erratic for us. A three month course here at Trinity (Digital Logic, ENGR 221L) can teach you all the rules necessary to build a computer using only AND, OR, and NOT logic. The equations of quantum mechanics and relativity are really just compact rules for describing almost everything that happens in the universe. On the other hand, one could spend a lifetime (or several) tracking down the stimuli for World War I or analyzing the genius of Bach. Engineers, and more generally scientists, like rules because they are safe and simple ways of reaching a definitive conclusion.

Society follows vague and ever changing guidelines of dress, actions, and tastes. This intimidates many engineers because they never know what is "right". Instead of trying to keep up with the times and risk being out of style, engineers often denounce society's morphism and remove themselves from the general population. This is a very

simplified view because it predicts that all engineers will make a complete cut with society. Instead engineers tend to pick a few "scary" elements in life and remove them from their concerns, i.e. physical appearance.

Recently engineers have been going through a transition that has brought them back into society. You may be next to an engineer right now and you wouldn't even know it! The glasses are gone, the gym is a place they inhabit, they can dance and sing, or even read e.e.cummings. What has happened?

A handful of engineering schools, and Trinity is certainly a leader among these, have developed a new idea in educating engineers. The argument for this novel idea is as follows:

- 1) Engineering is the practical application of science to solve everyday problems.
- 2) Everyday problems arise and are solved in the context of society.
- 3) If an engineer is not aware of society, how can they solve its problems?
- 4) Therefore, the best engineers are in touch with society!

How does a school curve the "natural" behavior of engineers? Trinity's answer is to allow their engineers to see a broader picture of the world. I am required by my department to take 8 classes (nearly 1 full year) unrelated to science or math. Anthropology, religion, music, theater and dance, and philosophy classes have enabled me to engage in some very fruitful conversations with noteworthy people from diverse fields.

Let us compare the performance of a liberal-minded Trinity engineer to an engineer at, say, MIT. A Trinity engineer has taken three years of technical classes, where as a peer at MIT has taken four very rigorous years. Who is the better engineer? I can assure you that the MIT engineer will be much better equipped to solve Schrodinger's wave equation or find the residue of a complex contour integral. , On the whole, MIT will place their engineers in higher paying jobs after graduation. How can I compete with my peers when they are so much better at solving problems than I am? Look again at step one in the argument above. Now lop off the last prepositional phrase and you arrive at the MIT philosophy of engineering. You may say "So what?" but think about this: How useful to society is a solar powered flash light? Everyone knows that a solar powered flashlight is useless, but some engineer from MIT actually built one! I am not knocking MIT, I respect them and other such engineering schools very much. However, a Trinity engineer can enter society and identify its problems much more accurately and efficiently than an engineer with only a technical background.

We have established that there is more to engineering than solving random problems. What about employment? How can schools like Trinity compete? When a technically talented engineer enters a job, there is always a manager or CEO deciding which

problems need to be solved. Unfortunately, many high level executives know nothing about engineering and request things that they do not fully understand. Enter Dilbert, the frustrated engineer who is trapped in a little cubby unable to cope with a technically incompetent boss. Is there any way out for Dilbert? Probably not because he is viewed by his superiors as a robot who solves equations. After a few years Dilbert will either quit or become so fed-up he will give only 50% to his employers instead of 100%. Big companies have finally realized that engineers like Dilbert are lurking in their cubicles. The way to avoid the sad outcome of Dilbert's employment is to either give him a voice in the formulation of problems, or better yet promote him to a manager's position.

With this in mind, who is the better engineer to hire? One who shoots up like a flame and quickly dies or one who begins as a small spark and grows into a raging fire? I believe most companies want a raging fire even if they have to wait for it. Trinity and other liberal arts schools are working hard to produce engineers who will enter a company and rise to the top.

Several consequences have arisen from the shift toward a liberal engineering education. Trinity offers a B.A. in engineering to supply companies with bosses who do understand what they are asking of their co-workers. Many engineers are becoming successful entrepreneurs because they truly understand how their product fits into society. Engineers are invited to speak for themselves at important conferences and sales events. More popular books are being written about engineering.

Most importantly, women are entering engineering! This is a great leap forward for the field; a leap which is long over due. Go back to the definition of engineering - the practical application of science to solve everyday problems. First of all, women are as capable in the sciences as men, so there is no reason why they should not enter engineering. Secondly, women bring a new perspective to the field. Comprising more than half of the world's population, women have problems that men can never understand. Women are finally being allowed to tackle their own unique problems. Third, the presence of women on engineering teams establishes a beneficial positive feedback system (excuse me for using engineering terms) for both sexes. The presence of women in the work place provides for a larger cross section of society. This establishes a more comfortable, stable, and efficient working environment. The more the environment becomes better suited to accomplish it's task, the more women are being encouraged to enter engineering. And so goes the positive feedback cycle.

So, picture a typical engineer.

Now have an imaginary conversation with your engineer.

Where do they work?

What gender is your engineer?

Get the point?

--Joe Tranquillo

“The great tragedy of Science—the slaying of a beautiful hypothesis by an ugly fact.”

*--T.H. Huxley
(1825-1895)*