

SOCIETAL BARRIERS AND STRATEGIES FOR SUCCEEDING IN THE TECHNICAL SCIENCES

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The Navy fighter pilot movie thriller Top Gun portrays the training of a neophyte pilot out to clear up and revenge the memory of his father who also was thought to be a daring pilot. However, the movie has a special twist to the love story at the beginning of the film calculated, to catch the audience by surprise ... The hero meets a beautiful girl in a bar and plots to pursue her. The beautiful girl appears the next day in his first class as guess who? ... an astrophysicist who is his first professor. The irony of this clever beginning, calculated to surprise, is that the viewer would never guess that a woman, and a beautiful one at that, would/could/should ? be an astrophysicist. The film thus cast two stereotypes out the window ... I congratulate the script writers.

Or take the real case of a female M.I.T. student majoring in aeronautical engineering. She recounted that she had to fight all her life to retain her interest in aeronautics; her friends thought she was crazy, her mother told her she'd never find a job? How many men would be aeronautical engineers in the face of such contrary pressure?

How many of us learned, as women scientists, about Maria Mitchell an astronomer who computed data for the U.S. Nautical Almanac Office way back in 1849? She discovered a new comet and became the first awardee for astronomical research given to an American by a foreign government, Denmark. She was also the first female member of both the American Academy of Arts and Sciences and the American Association for the Advancement of Science. Indeed did we or the world know, that several other women like Annie Jump Cannon and Cecilia Payne-Gaposchkin, made substantial contributions to astronomy over the last 150 years?

Because there are members of our 1991 society that still consider science essentially the business of men, and not women, we must put this bad situation behind us. This is why WEPAN is rallying us at a most important conference to assume a NATIONAL INITIATIVE to break down the societal barriers that block women's strong presence in the technical sciences. In these two days we are mustering our brainpower and developing strategies to change the future and correct the past world of science for women.

I've talked about the movie Top Gun and it's surprise element. But the good news is that millions of film viewers did see the film Top Gun. The good news is that there are now, across the country isolated, but strong and effective efforts, strategies, to correct the poor participation and career involvement of women. One of the positive new thrusts at the national level has been the decision of the National Research Council of the Science Academies to back a permanent special committee of the Office of Scientific and Engineering Personnel (OSEP) to make changes in our current science dilemma with reference to women. This new committee has been authorized to monitor efforts within and outside the Academy complex, convening working groups, proposing research and studies and gathering and disseminating significant data.

But the bad news is that although women make up more than 51% of the population and they are 45% of the total work force and 50% of all people in professional or related occupations, they are scarcely more than 16% of working scientists and engineers. Of that percentage less than a fifth are in the hard sciences or in engineering. Amazingly, of those, and there literally hundreds, wouldn't you think they would be good enough, — distinguished scientifically —, to be represented in significant numbers in the prestigious National Academy of Science? Not so, in 1977 only 2.3%

were members, in 1987, the number increased to 3%; in 1989, it was up to 3.5%. But optimism is in order. This spring among the new 1991 members a full ten percent or 6 of 60 new members were elected. So you agree I'm sure, that the male selection psychology merits study. Serious study must be made to determine why distinguished women researchers are essentially overlooked by the male prestigious scientific community. We are invisible at the bottom and at the top. Such data also suggest that strategies are needed by the members as well as by us to make a change in this serious gender gap in the Academy. There are then two issues ... one, the relatively "invisibility" of superior contemporary women scientists and two, the serious underrepresentation of females moving through the pipeline.

In order for me to address the strategies needed to make a difference in the number of women scientists I will present strategies to coincide with the life pathways of females from childhood to adulthood. What happens to us that prevents our final entry into science and engineering careers?

For a point of reference let us use the analogy of the filter for science. What finally passes through a filter is determined by the size of the pores in the filter and by the concentration and type of particles passing through. Given equal numbers of girls and boys termed, the concentration, and types of particles, intelligence, which is equal for boys and girls, the only variable is the pore size. I postulate that the size of the pores (barriers to science if you will) is determined by socialization factors and the ability to handle mathematics, a teachable body of knowledge.

There are seven filters of science that are present in the life of a women scientist. They are: 1. Early childhood or preschool experiences. 2. Elementary school where basic attitudes of parents and teachers are important. 3. Junior high school where shaping of broad interests and aptitudes begin to appear and when flexibility and curiosity are at peak levels. 4. High school when sexual awareness can maximize or diminish future learning directions if handled poorly. Who ever picked the homecoming queen because she is an honor student in math? 5. College, when academic paths are shaped and new fields opened for exploration. 6. Graduate school when encouragement must support and reverse ambivalent factors shaped by society. 7. Post-graduate work preparatory to a career.

The first filter is socialization in the preschool years. The socialization process begins at birth with pink blankets for female babies. The infant and preschool period is the first filter. Children learn behavior through contiguity. Sex-typed behavior is shaped very early in the home. A female child soon learns to act like her mother, usually through positive reinforcement. She rapidly identifies her own sex. Verbal symbols from mother give very early instructions in sex-typed behavior. The appropriateness of certain sex-linked behavior is readily learned. As a female child enters the preschool period, she learns that dependency and passivity are generally acceptable, as are certain toys specifically designated for her sex. Physical aggression is not a behavior appropriate for female children, but it is applauded for boys. Stereotypes of female passivity for girls or masculine aggressiveness for boys develop not only from body concepts but by observation of highly visible differences in the people they see, both in the home and outside it.

STRATEGY #ONE — Encourage and sensitize young couples to realize the important role they play in the socialization of their young children. Selection of the toys they play with, behavior approval that rewards girls for passivity and boys for aggressive performance, are all culture bound and often gender labelled. Prospective parents can understand value neutral toys that are shaped not by gender but rather by the interest of the child as an early learner.

The second filter to science is the elementary school experience and its socialization effects. Math, for example is typed as a "male" subject. Early grade school teachers, the majority of whom are women, are themselves rarely comfortable with math. Much research has shown that women have been subtly, undermined when it comes to their confidence in math. Although there are no measurable differences between the sexes in the early years as far as mathematical skills are concerned, after elementary school, boys begin to excel girls. By the time they take the Scholastic Aptitude Tests in high school, boys score an average of 50 points higher than girls on the mathematical portion of the exam. As girls and boys proceed through school, they are subject to pressures to conform to societal expectations of sex-appropriate behavior and dress.

The third filter is the junior high school experience. Female students themselves develop lower opinions of their abilities during these years. As girls and boys progress through school, their opinions of boys grow increasingly more positive and their opinions of girls increasingly more

negative. Girls are more likely than boys to attribute poor performance on math tests to their own personal characteristics and habits. They are less likely than male peers to be optimistic about grades they will receive. Girls often suffer a loss of occupational potential. Girls' visions of occupations open to them are likely to be limited to four: teacher, nurse, secretary, or mother. Boys of the same age respond with surprising range of things they can do when they grow up.

If we are going to combat the early socialization regarding math and science for girls we as parents and teachers must carry out planned programming in and out of school for girls. We must talk about career options to nine year olds. We must help them master numbers and mathematics and physics. A few years ago I visited a Saturday Science School in Atlanta where boys and girls were immersed in an exciting teaching mode called Discovery Learning. In that classroom of 10 to 14 year-olds I saw the excitement and fun in solving geometry problems with great success by equal numbers of girls and boys. Being verbal and talking about mathematics problems in the classroom helped all students visualize the logical components of reasoning.

STRATEGY #TWO — We can develop a program that would involve extensive training programs in math for volunteer mothers in elementary and junior high schools. This program could also send women who are math professionals into the schools to work an hour or two a week with students, especially with students who show an aptitude for arithmetic. They might also help the teachers who need a refresher session or two.

Strategies can also include written or visual media. How about a Nancy Drew mystery scientist series? Let us create a TV teenage series like an older version of Sesame Street for junior high girls and a few boys. A series of films should be made and distributed to be viewed by girls in grades 9-11. Films describing positive career options for women in science could be used as a jumping-off point for discussion and follow-up in conjunction with ancillary materials which are also available. Girls' organizations such as the YWCA or YWHA and the Girl Scouts should be encourage to develop and promote programs for girls in science. For example, such programs might involve the awarding of merit badges for projects in electrical engineering and study projects in various scientific fields. Mills College in partnership with Lawrence Livermore Lab has a full written program that is titled "I'm in Love With Electricity."

The 4th and most critical filter, the high school years, results in a decline of interest in mathematics and therefore enrollment in math courses. Three or four years of high school mathematics are required in most colleges for a major in science. College-level mathematics is a prerequisite for math, science, and engineering majors. Women students are not encouraged by family and society to "stick it out" with mathematics; men are, because certain careers they want will require mathematics backgrounds for college courses. In high school, both boys and girls show some clear evidence of sex-stereotyped attitudes regarding mathematics: According to the Ernest study, 45% of fifth-grade students go to their mothers for help with math homework, 18% consult their fathers. By high school the picture is reversed, with 50% of both boys and girls requesting help from their fathers and 12% requesting help from their mothers. Clearly, by high school, both boys and girls have decided that math is a male subject.

Inadequate secondary school math preparation is the chief deterrent for women who might otherwise choose to major in one of the sciences in college. Teachers, guidance counselors, as well as parents, must reevaluate their own attitudes and prejudices about math being a "male" subject in order to more positively influence girl students. This kind of change is not likely to occur in the short run.

It is here that we must sponsor science-awareness activities. As a challenge for us, we as scientists can assist in developing a school wide or community wide program of motivational tactics for teenage girls and their mothers and fathers. There can be after school science/social clubs. National girls organizations could rewrite policy directives that now include science literacy for youth, which include millions of young women in their membership.

A creative strategy now exists at CSUF funded by the National Science Foundation. Their program selected 35 high school female students good in everything except math. These rising senior students from area high schools came to a summer residential program and were immersed in advanced summer school math courses on campus. Taught by college instructors. They received a bonus to eliminate their need for summer jobs. They spent 5 days a week receiving 6 hours of intensive math for 4 weeks from a college professor and two female high school teachers. The students must commit themselves to four weeks for more classes next summer.

College is the fifth filter where pressures from the external campus and peer pressures can be even greater. There is a lack of encouragement for most college girls who have the ability and interest to major in science. This lack of encouragement for a science career on the part of an adviser in the early college years is partly due to a realization that the employment opportunities open to women scientists are more restricted than those open to men.

The disappointing female enrollment in college mathematic courses is exacerbated by the higher attrition rate for females. As the level of difficulty increases and more time and effort is invested in course preparation, it seems reasonable to assume that college women, like their grade school sisters, are likely to conclude that a poor grade is due to a lack of math ability rather than to the lack of effort, and, accordingly, may drop the course. And so as women proceed through life and through our educational systems, the filters get finer and finer, until few manage to move through them at all.

Academic advisers play a large role in determining how many women will continue to maintain an interest in science in the high school years. Unfortunately, these advisers often labor under misconceptions regarding the nature of work in scientific fields, believing it to be more demanding of time and commitment than jobs in other fields. Such ideas, however, fail to take into account the changes that have occurred in scientific fields.

For college science women students: Develop mentor programs for undergraduate women via: One-on-one with females in industry as a junior "little science sister." Plan lecturers or receptions as role model scientists on campuses ... in communities ... on site in companies. Monitor and improve the "classroom" environment once females reach college. For example, it has been expressed in several quarters in engineering and graduate school classes that there can be a problem of foreign-born male graduate assistants or faculty from cultures with a different type of view of the role of females in society.

Breaking the math/science barrier for adult women is perhaps one of the most difficult to break through. Many courses can be designed and taught through numerous advising centers now available as outreach functions of colleges and universities. We tried such a program at my former institution — Douglass College, Rutgers University — with quite a bit of success. Within our return to college program, we decided that a group of 12 older women was a critical size. The leader was a woman skilled in teaching math, and she approached the problem by combining math skills with group dynamic sessions. The women shared anxieties and talked to each other about how awful they were with numbers and the meeting became a mixture of free confessions, complaining, and also learning how to be comfortable with the vocabulary and the operations necessary in pre-college math. As their confidence grew by practice and understanding the women in the group gained courage to use their information and eventually to take a college math courses. Numbers of women, those returning to college or those in community colleges, can be tapped, too. If they can overcome the barrier of the math problem, they can then be recruited into science.

Teams consisting of prominent women scientists and senior women graduate students should be sent to spend 48 hours with beginning women undergraduate students in science departments. This visit would include informal discussions, scientific seminars, and opportunities for informal discussions in which successful women scientists could explain personally how they reached points of success in scientific careers. Likewise, programs that work closely with industry or government research laboratories to allow apprenticeships for junior level undergraduate women scientists should be developed.

It is in the first year of college that many talented science-bent female students are lost. All the female professors that one can find should be pulled into a cohesive program including a residential study haven, such as that present at the Douglass College Project for Rutgers Women in Math, Science and Engineering.

STRATEGIES:

Establishment of strong support groups among women students taking the same courses. Improvement of study skills — basic! Availability of faculty who care about the science student and especially the success of women students — women professors (the few) and male professors. Student mentors for assistance in course work should be available and given instructions to help aggressively. Enhancement of academic performance we expect as an outcome, not "we doubt that you can do it." Readily accessible science faculty mentors. Knowledge of how to use the campus resources. Practice chemistry and math

exams with student mentor help. Informal meetings with professors, teaching the science and math courses. Availability of women faculty for personal counselling. Formal and pleasant group meetings two times a month for all intended and decided women in science majors. A science women's center with the help of Student Services. Early access to learning the computer. Need to develop strong student to student and student to faculty interactions.

The sixth filter is graduate school. As expected there is a drop in the number of women earning masters degrees after the baccalaureate degree in science and engineering. In 1986 that percentage of masters was $\pm 15\%$. Thus about 15% of women continued on for a masters and 22% of those earning masters continued to earn the Ph.D.

Pores in the filter for women are smaller including such barriers as financial support, personal marital plans, failures in personal/tutorial/apprenticeship system inherent in graduate school. The research laboratory is a social place with many intricate male/male environments that women find awkward or impossible to penetrate. Advice and strategy — before enrolling in graduate school and department, cross check to learn the number of women who earned their degrees recently, the number of female professors, the number of current graduate students who feel positive about their progress. It is here that a host of various barriers can exist. The senior researcher or mentor plays a pivotal role not only during graduate school, but in post-doctoral placement.

What can we do to help get more women all the way through to that final doctorate and a job that challenges her scientific talents and begins the path to the top as a member of the National Academy of Sciences? Your ideas during this conference will help as we share and follow through with implementation. Early on here are some strategies:

1. A set aside group of graduate fellowships for women like those of the National Science Foundation should be funded at the top research universities.
2. To assist women students at the graduate level, it has been suggested that there be established a data bank of responses of women graduate students are asked to record what happens in the science department in the early professional socialization. The material, gathered in the form of a questionnaire, would be extremely valuable. It has also been suggested that there be developed and funded a series of short or yearlong refresher courses, research internships, and/or combinations of these for women scientist who want to reenter their professional fields. The model of the NSF Summer Institute could be used, except that the students would be the reentry women.
3. A series of panels at the annual science professional meetings should cover the topic of "changing the barriers to science doctorates by women." The panelists should be male directors of leading research laboratories.
4. Lastly even women faculty with doctorates but not moving along in research need a new 2-year research award to establish a new research base elsewhere so they can be positive role-models for their undergraduate students, the department and the other research male colleagues.

The time for putting strategies in place is now. The time for us to change the contemporary oblivious behavior of those at the top of the scientific fraternity is now. It requires the cooperation of many sensitive, enlightened, motivated male scientists willing to make a difference at the science conference table and lab. For even though most of us know that between now and the year 2,000 more women, (51.5%) than men will enter the general labor force, we must convince others that our science and technology personnel problems will be horrendous if we don't move more women through the science pipeline now. It is in our national interest.

Let us turn our hopes and plans into a meaningful reality that begins today.

