Fabrics of Social Determinism dominate STEM education from kindergarden through tenure and beyond to NASA

By Jane Crayton

Introduction

From the education gender gap, to saturation overload, students in American schools are slipping behind in STEM (Science, Technology, Engineering and Math) education. Our brightest minds may not be challenged, even worse, they may never go inspired to create, develop or invent our nations next source of income, or better yet, our national pride.

We live in a time where technology is everywhere, and our economic wealth today, is partly because of our success at being an innovation-nation in technology and systems development. Since President Dwight D. Eisenhower signed the National Aeronautics and Space Act in 1958 we have seen a great rise in access to education especially in STEM subjects for all United States Citizens. However, in the last two decades, there has been a downward trend in the number of students graduating with STEM degrees, as well as proficiency in STEM subjects for students in public school. Similar to the drake equation which evaluates the possibilities of life in the universe; the reasons why STEM is loosing ground is the United States has a multitude of possibilities. We will examine several key factors in why the social fabrics of determinism still dominate STEM education from Kindergarden through tenure and beyond to NASA.

Decline of techno-innovation

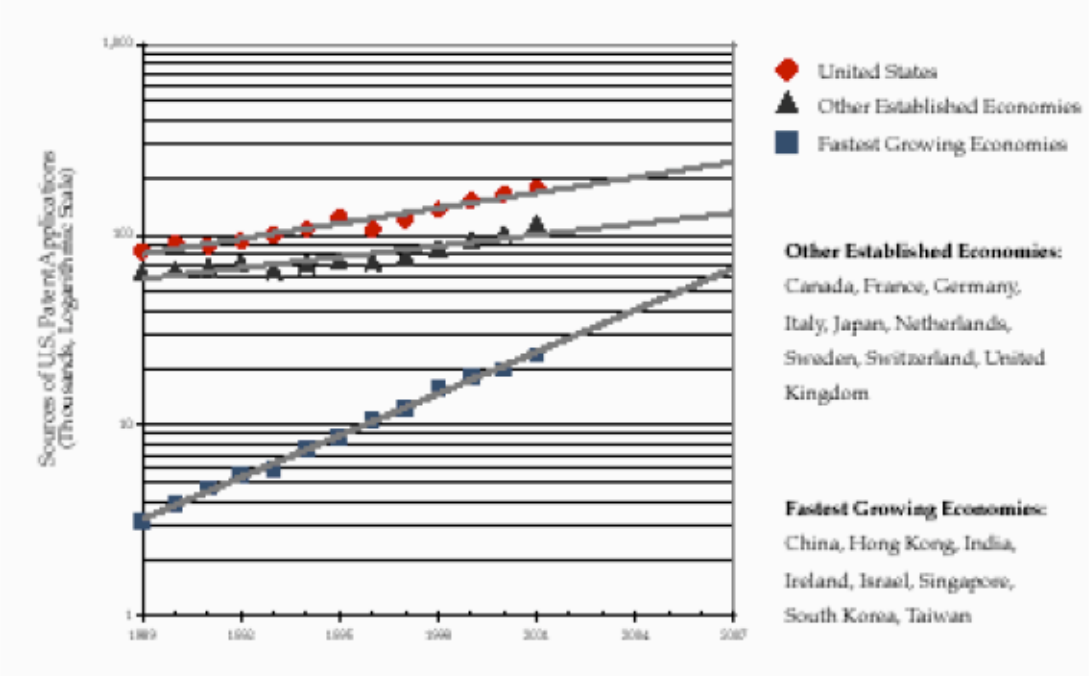
According to Dr. Mel Schiavelli, "Innovation begins with the talent, knowledge and creative thinking of a workforce. Highquality STEM education and learning environments that prize innovation and imagination produce graduates who will germinate new inventions, develop new products, and create new solutions to many of our world's most pressing problems."

However, innovation is apparently in great jeapordy in the United States. Once a leader in innovative technology research and development, now America has lost her lead on technology as we compete with countries like China, Korea, India and Tiwan for exports in technology and services for these new mediums.

> Some consequences of this new global science and engineering activity are already apparent—not only in manufacturing but also in services. India's software services exports rose from essentially zero in 1993 to about $10 billion in 2002. In broader terms, the US share of global exports has fallen in the past 20 years from 30% to 17%, while the share for emerging countries in Asia grew from 7% to 27%. The United States now has a negative trade balance even for high-technology products.

> That deficit raises concern about our competitive ability in important areas of technology. (Gathering Storm)

In addition statistics show a decrease in invention and US patent applications (image 1), coincidentally we also are now the lead importer of technology. This is a complete role reversal from twenty-five years ago. How did we fail to integrate STEM fully into our American education model? How did we fail to inspire our youth with inventive behavior? Is it our short attention span, that which has allowed us to become distracted, especially by media?



(Image 1) US patent applications. Source: Task Force on the Future of American Innovation based on data from National Science Foundation. Science and
Engineering Indicators 2004, Appendix Table 6-11. Arlington: APS Office and Public Affairs.

Alarmingly there is current data that suggests children and youth are consuming technology and media at alarming rates. We have shifted from an inventive developmental producer of technology to a media driven technology consumer. Our youth are no longer excited about images of Apollo, or landing on the moon. How did those images become mundane while images from You Tube become the next fad? Is it interactive connectivity and stimulation?

A recent study by UCLA researchers -- Dr. Gary Small, Teena D. Moody, Ph.D., and Susan Y. Bookheimer, Ph.D which will soon appear in the American Journal of Geriatric Psychiatry, is reporting that using Internet search functions fires brain neurons. The study suggests that web surfers with experience registered a two-fold increase in brain activation, which could suggest why it is also so addicting and or interesting.

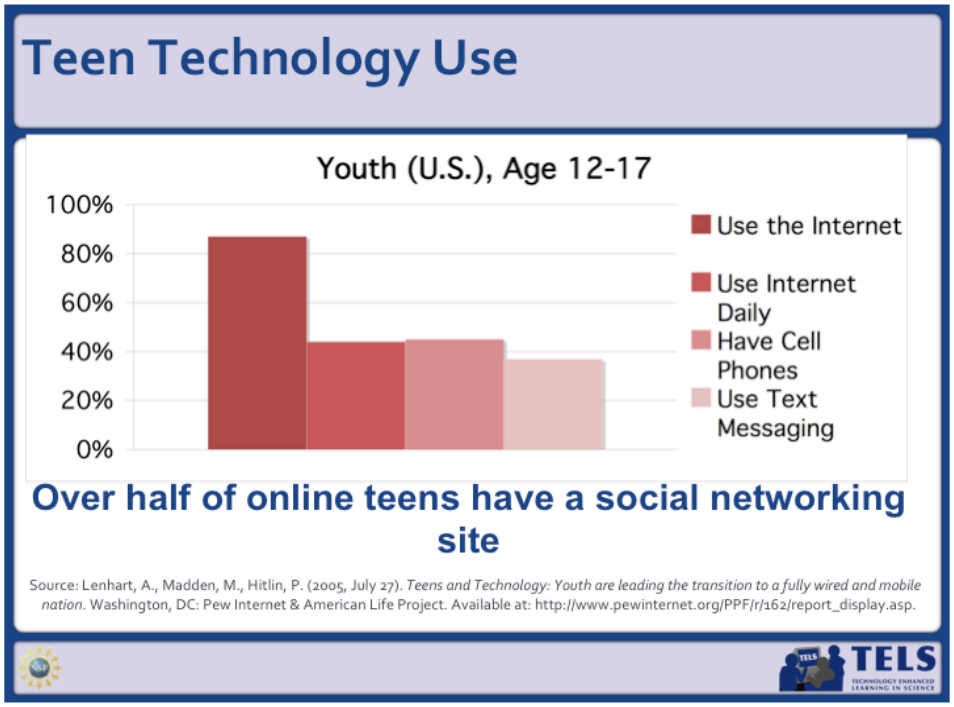
Described by the research team, "Mental stimulation similar to the stimulation that occurs in individuals who frequently use the Internet may affect the efficiency of cognitive processing and

alter the way the brain encodes new information." Small explains, "Internet searches require the brain to retain important information in working memory and to comprehend the displayed graphics and words, thus having to fire more brain neurons."

So we can understand why youth in America are attracted to internet technology, maybe its because they are more stimulated by media and technology than a teacher standing at the front of the class room talking at them.

Today, the youthful imaginations take them further than Apollo and flutter images on a black and white screen. The techno-media revolution can drive that vision and excitement, through its endless plethora of sources. Youth trends are not something to be dismissed, they are the leading consumers in our nation, and they are our future makers and shakers. But, if they only know how to consume, they how will they support our future American economy? We need to make sure that our teens use technology wisely, to further their education, and hopefully stimulate inventive behavior.

Lenn Millbower explains how the Internet is also a useful tool, when used wisely. "The Internet make reams of knowledge available. And, although you have to sift the information carefully for truth, anything you need to find out -- anywhere in the world -- is likely to be available at the type of a few words." So how do we get our youth to use technology wisely, and responsibly? Current trends for technology and media use, show them steadily increasing, with numbers of teens using social networking sites as almost 50% (Image 2).



(Image 2)

However according to Schiavelli, “seeing real-life examples motivates, too. Many young innovators have fostered a new kind of "cool" and can serve as role models. Facebook developer Mark Zuckerberg invented the social-networking site at age 19. Bill Gates was 19 when he started the first microcomputer software company. Napster file-sharing software was developed by 19-year-old Shawn Fanning. Apple was founded by 21-year-old Steve Jobs and 25-year-old Steve Wozniak.” Locally we have Nathan Sidle of Spark Fun, a local DIY electronics enterprise.

So technology use is cool, and even development is “cool”. So why then are we still lagging behind our Asian competitors? Are we in a ‘catch 22’ with technology, did we miss something along the way? How about the corporate mindset, how about marketing, and our consumer attitudes, maybe a lack of techno-ethics?

Majoring in a science or technology discipline does not guarantee a Porsche in the future, but it also does not limit successful careers to so-called techno-geeks. The stereotypes of the techno-geek are changing, and because of this we would expect to seem more participation from non-traditional STEM learners, but somehow the social stigmas still affect students decisions to focus on STEM.

Why STEM Education is Important

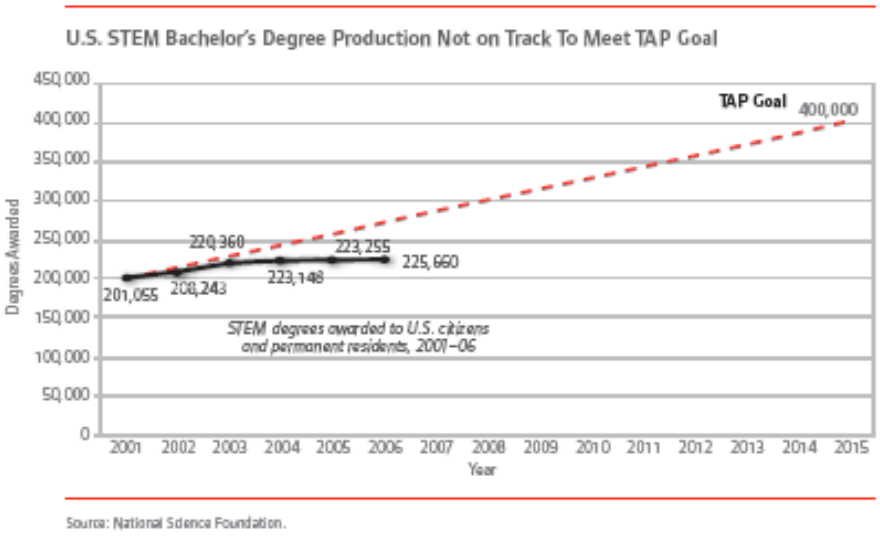
Dr. Schiavelli suggests, “Engaging and rigorous undergraduate STEM education provides the foundation for the STEM workforce, for advanced study, for well-prepared K-12 teachers, and for an educated 21st century citizenry.”

What I think is important about this statement is the term “21st Century Citizenery”. What does it take to be a well educated, and productive citizen in the 21st Century, and what are our moral and ethical obligations to learning and teaching STEM as a part of critical societal development fostering an inventive workforce?

Currently, there are just a few pieces of legislation to support STEM education nationwide, with even less dollars committed to the proposed projects. Infact, over the last several years, EPO (Educational Public Outreach) funding has slowly been disappearing from the NASA budget. This is ironic considering they face a diminished pool of STEM qualified cantidates in the future for NASA missions.

Dr. Schiavelli suggests in his essay Innovation stems from scientifically educated workforce. “STEM is now, and will increasingly be, the universal languages of the global marketplace. The nations that invest heavily in STEM education, research and the development of a skilled workforce will enjoy leadership positions. American students, however, are falling behind in the essential subjects of math and science, putting our position in the global economy at risk.”

According to the TAP Report, students who graduate with STEM degrees have greater opportunities for future employment. “The Bureau of Labor Statistics projects that employment in science and engineering occupations will grow 70 percent faster than the overall growth for all occupations.” and “STEM graduates on average enjoy better employment prospects and higher starting salaries than graduates in non-STEM fields.” (TAP Report) However, the table below illustrates that current statistics for STEM Bachelor degree production is not within the standards set out by the TAP Foundation.

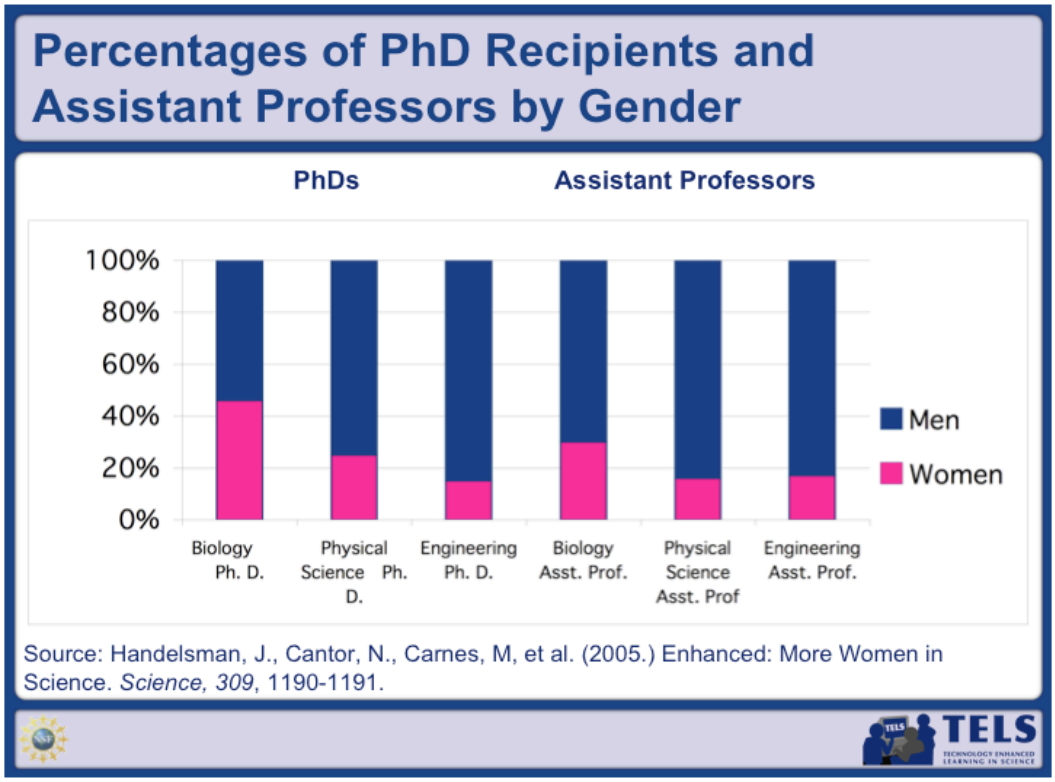


Gender Gap in STEM and NASA

So are there any explinations for the lack of STEM degrees, and lowered STEM scores of American students? According to Schiavelli, “NASA's motto is simple: "For the benefit of all." We should adopt a similar view of STEM education.” So, when we start to address the gender gap, we can clearly see how social and gender issues become the next big obsticle for America’s STEM Education Plan.

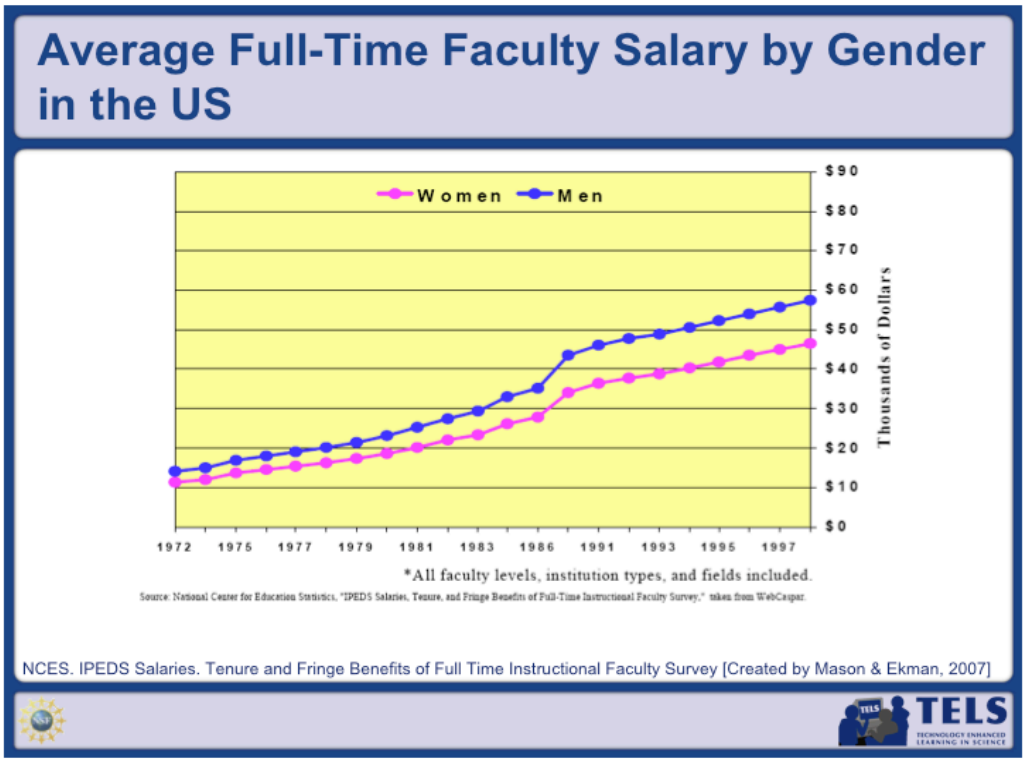
> Only one of NASA’s planetary science flight missions in the past 30 years has been led by a women scientist as Principal Investigator. The number of senior women in the field is small, but women are still underutilized, as seen by a cohort age analysis correlating with median ages for various key science roles. Worse, the more junior women are not joining missions as Co-Investigators and Participating Scientists at rates approaching their representation in the field of planetary science. (Susan Niebur)

In a study conducted in 2005 Do babies Matter? the percentage of Female PhD recipients and Assistant Professors is clearly decreasing, and the only section with a slight increase is the field of Engineering, which is comparitevly still the lowest.



What is clearly worysome is that the % of women majoring in these critical STEM degrees are decreasing, especially at a time when women now have more access and options to study at Universities.

According to Dr. Marcia Linn, "Women drop out of the tenure trajectory because they choose to have a family." Comparetively on 55% of tenured women choose to have children compared to 74% of men.



In the report on Do Babies Matter? "First, as noted, women with Ph.D.s are far more likely to marry men with Ph.D.s than are men and that in the early child-raising years women are far more likely to defer to a husband's career (Nerad & Cerny, 2000) Therefore, accommodating two career couples cecomes and important "family friendly" policy. (Mason, M.A. and M. Goulden (2004))

> Before they quit, many women described situations in which husband with highly demanding jobs were simply not around to help out with parenting or domestic life, but husbands' absences (occasioned by committments necessary for their career advancement) increased after women were home, making their husbands even less available than they had been before. This had been Wendy's experience, and it was also Moira Franklin's. She described how her husband's involvement in his career as a tenured professor at a prestigious research university grew as her own careen in engineering was cut short (and also suggests how her working would have compromised the research agenda that is so critically importnat to his academic success). (Stone. 192)

This is an important aspect to try to understand, as Moira Franklin describes her support of her husband, as an acceptable reason for giving up her own interest in engineering, she is placing herself

subserviant to her husband. Why are women abondoning their career goals for families, is it pressure from their husbands? Is is pressure to keep the family together, least they end up another single parent statistic? Or maybe they aren't encouraged, when they have to work harder and longer for less pay?

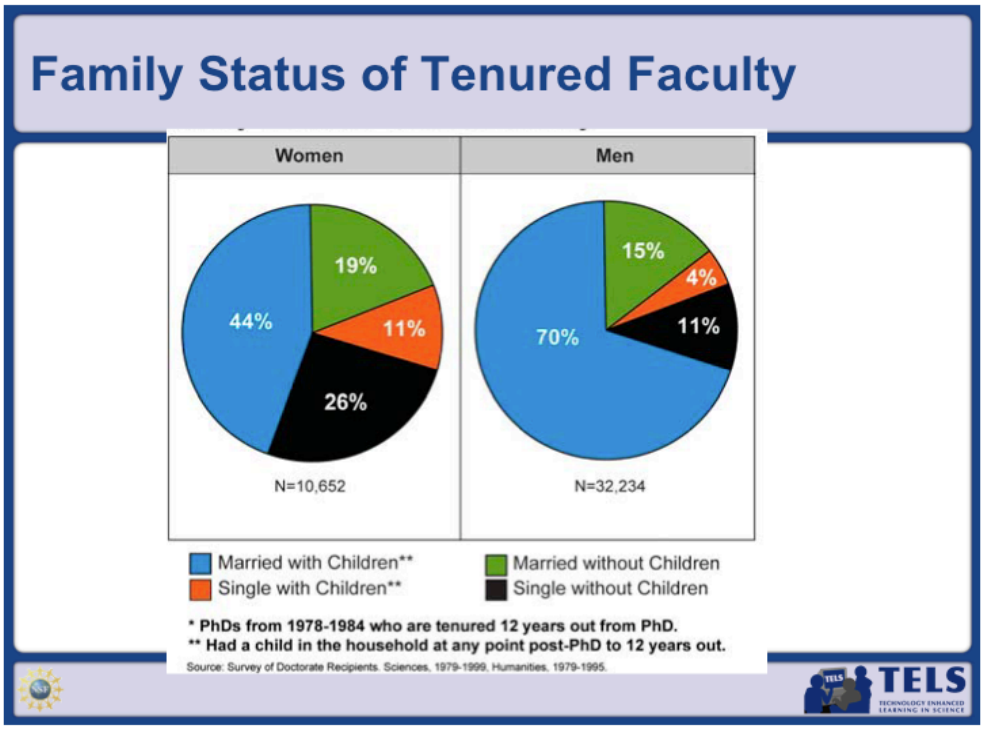
Stone also referenced in her book Opting Out. Why women really quit careers and head home. "Just under a third of husbands indicated a positive preference for their wife to stay home. For some husbands, this preference reflected more traditional orientation." Since so many of the STEM graduates are of a more traditional background, immigrating to the US for education in STEM during the space race, cold war, and post WWII, many tenured male professors, whom have wifes, likely have stay at home wives.

If we were to compare the number of spouses whom were home-makers as their job, then the numbers between sexes would be staggering. One could imagine that possibly half of the males whom were married, may have a stay at home wife, where as likely all the husbands of the tenured women, likely have jobs or tenurship themselves.

In addition according to the National Academy of Sciences there is a trend against learning STEM by many people, "many adults with whom students come in contact seemingly take pride in "never understanding" or "never liking" mathematics." (gathering storm) This is an example of an underlying social determinant which helps in turning off the options for possible STEM learners. However these kinds of social stigmas are no different than many of the other "micro-inequities" which exist within our educational system and society as a whole.

Non-traditional women in STEM

Moreover according to Mary Ann Mason, "Discrimination against job candidates who are pregnant or have children is a very real part of gender discrimination. Some scientists may believe that women who have families cannot be serious scientists because academic science demands exclusive attention to research. But they do not hold the same beliefs about male scientists with kids. In fact, research shows that male scientists are far more likely to have children than female scientists; two years after their Ph.D.'s, nearly 50 percent of men, but only 30 percent of women, had children."



> Subtle maternal discrimination is difficult to deal with, but concrete measures, such as parental leave, child care, and other support at both the student and faculty levels, would go far to reduce this unnecessary loss. (Mason)

It is ironic that the trends suggest that in order to be a successful female scientist, you should not have children. And you could assume that with only 11% of tenured professors as being a single parent. Considering most single parents are female, I say, there is a huge market of untapped potential waiting with single mothers.

According to Wendy Pan, "Single parent family households have become a common occurrence in the United States, and the number of these types of households has been on the rise for the last several decades. Currently in the United States, according to single parent family statistics, there are over 13 million single parents." And "Nearly 85 percent of these households are headed by a female, while the remaining households are headed by a male."

This could suggest an entire demographic missed, a demographic, which would greatly benefit from STEM education, allowing them to better provide for their children and families with skills that will help their employability for decades to come. These are our nations poorest people on the average, and many of them are very hard working. However, we are not targeting them, and instead we are alienating them and socially determining them to a 'lower class' and to be 'subservient' to the higher educated. However, this is an opportunity to engage women, and their

children, many of which are not being educated to STEM standards either.

So as it stands, women are not being encouraged enough, and aren't being given the right opportunities to learn STEM. In addition, women are not in enough leadership type positions currently to warrant a real foot-hold in the NASA door or in STEM academia. Although many more women are being exposed, not enough women are choosing to stay, and that is a core problem within the STEM community and education at large.

> Worse, the more junior women are not joining missions as Co-Investigators and Participating Scientists at rates approaching their representation in the field of planetary science. In fact, they are underutilized in these roles not by a few percent, but by greater than a factor of two. The pipeline of women gaining mission experience today is increasing, but it is not keeping pace with the rate that women are now choosing to stay in the field for postdoctoral studies and beyond. (Susan Niebur)

One of the best ways to include more women, especially non-traditional female students to see STEM degrees as an option is to, "Increase options for women who wish to balancefamily and career in academia." (Stone) However I believe that we still have to deal with issues of micro-inequities and social determinism before we can really find a solid solution to this gender gap.

Social Determinism and the effects of micro-inequities

Micro-inequities are ways in which people are ignored, disrespected, undermined, or somehow treated in a different (negative) way because of their gender or race (or some other intrinsic characteristic).

A micro-inequity can be very micro. It can involve an action or words or even a tone of voice or a gesture. The inequity can be a deliberate attempt to harm someone or it can be unintentional, rooted in a person's perceptions about others. (**Observation on Micro-inequities**)

In regards to Jet Propultion or the Aries 5 launch.
"Boys with toys!"
"Can you feel the power"
Referring to the rumble from liftoff of the phallic like Aries 5.

In response to a woman speaking-out about micro-inequities:
"don't be so sensitive"
"Man hater"
"She must be on the rag"

Image of typical scientist displayed in media.
"old white and crazy" (Nutty Professor, Dr. Jeckle, Mr Hyde,)

> 5 female students of 21 total students in ASTR 4800 at UCD 2009.

> Even if most people support the general concept that people should not be disrespected or marginalized because of gender or race, in reality quite a few people are willing to overlook micro-inequities. It is certainly easier to label someone as oversensitive or too quick to see things through the notorious gender (or race) lenses in a mundane situation than to deal with the ambiguity of identifying a micro-inequity. (STATUS)

Sometime you can see the micro-inequities and other times you can hear it. Sometimes it is subtly implied. However, not many women even pick-up on these incidences, or rather have they also been trained to blow them off, so they will not be labeled a "feminist"? Many women who are working toward degrees in STEM often haven not had the opportunity to be educated in ethics and humanism, let alone feminism and human rights issues. The social sciences just aren't pushed enough in the social sciences, and maybe its because there is another underlying societal view of these issues not being real science. However, I believe this lack of ethical development for both women and men of science is contributing to the social determinism of our STEM education system.

Could ethics help change the effects of micro-inequities and discrimination? Because according to STATUS, Women in Astronomy, "Whatever the source and however minor each separate event, over the years the cumulative effect of these little incidents, words, and gestures on an individual and on various segments of society (academia, business, even within families) is not so micro." (STATUS)

Current Legislation and STEM Initiatives

In 2006 and beyond, NASA will continue to pursue three major education goals:
-- Strengthening NASA and the Nation's future workforce
-- Attracting and retaining students in science, technology, engineering and mathematics, or STEM, disciplines
-- Engaging Americans in NASA's mission

> STEM Education Policies

> Nationwide-H.R. 1709 establishes a committee under the National Science and Technology Council that has the responsibility of coordinating federal programs and activities in support of STEM education.

> Hawaii—Act 111 establishes programs in STEM fields such as engineering,

computing and robotics, offered through the University of Hawaii, various Hawaii community colleges, the Department of Education, and other private businesses.

Kentucky—Act 177 provides an alternative route to STEM teaching certification for veterans.

Massachusetts—Chapter 29: Section 2MMM establishes the Massachusetts Science, Technology Engineering, and Mathematics Grant Fund or Pipeline Fund to increase the number of students in programs that prepare them for STEM careers.

Washington—HB2817 establishes a state priority for higher education institutions to encourage enrollments in STEM programs.

American Council on Education Center Point. 8/12/2009 Washington, DC 20036
http://www.acenet.edu/AM/Template.cfm?Section=CenterPoint&Template=/CM/HTMLDisplay.cfm&ContentID=33406

Building diversity into STEM and EPO

According to Minatiya Dawkins of the American Council on Education, "Building awareness about STEM careers among non-traditional learners and underrepresented groups and providing them with multiple pathways to education and training for STEM-related professions are equally important. " Not only do we have to create an environment that encourages these students to say, we have to entise them to come, by supporting them as diverse individuals with changing needs.

What are the sorts of things that help recruit women? Here are some examples from the report:

• Increased institutional efforts in signaling the importance of a gender-diverse faculty. This might be accomplished by increasing the frequency of positive declarative institutional statements, by establishing a committee on women, by exercising close oversight over the hiring process, or by devoting additional resources to hiring women.

• Modified and expanded faculty recruiting programs. Consider, for example, creating special faculty lines earmarked for female or minority candidates, ensuring search committees are diverse, encouraging intervention by deans when applicant or interview pools lack diversity, and systematically assessing past hiring efforts.

• Improved institutional policies and practices. These might include inserting some flexibility into the tenure clock, providing child care facilities on campus, establishing policies for faculty leave for family or personal reasons, significantly stepping up efforts to accommodate dual career couples, and continuing to offer training at all levels to combat harassment and discrimination and to raise the awareness of all campus citizens.

• Improved position of candidates through career advising, networking, and enhancing qualifications.

• Defining searches broadly to encourage a more diverse applicant pool;

• Posting the job advertisement in a wide range of outlets;

• Contacting professional associations that represent women (e.g., the Caucus for Women in Statistics, Society for Women Engineers, Association of Women in Science, etc.); and

• Evaluating the applicant pool during the search to determine if sufficient numbers of women are applying. (SOURCE Women in Astronomy)

Fran Bagenal suspects, "the most important factor is asking qualified women to apply. So… are you a qualified woman, e.g. less than 10 years out from PhD, couple publications per year, some significant first-author papers—and a moderately thick skin? Apply, apply, apply! You have nothing to lose."

Interesting, considering the TAP report suggested that, "57 percent of the women reported having a faculty mentor—a difference approaching significance." And "women were more likely to report having a mentor in electrical engineering and physics."

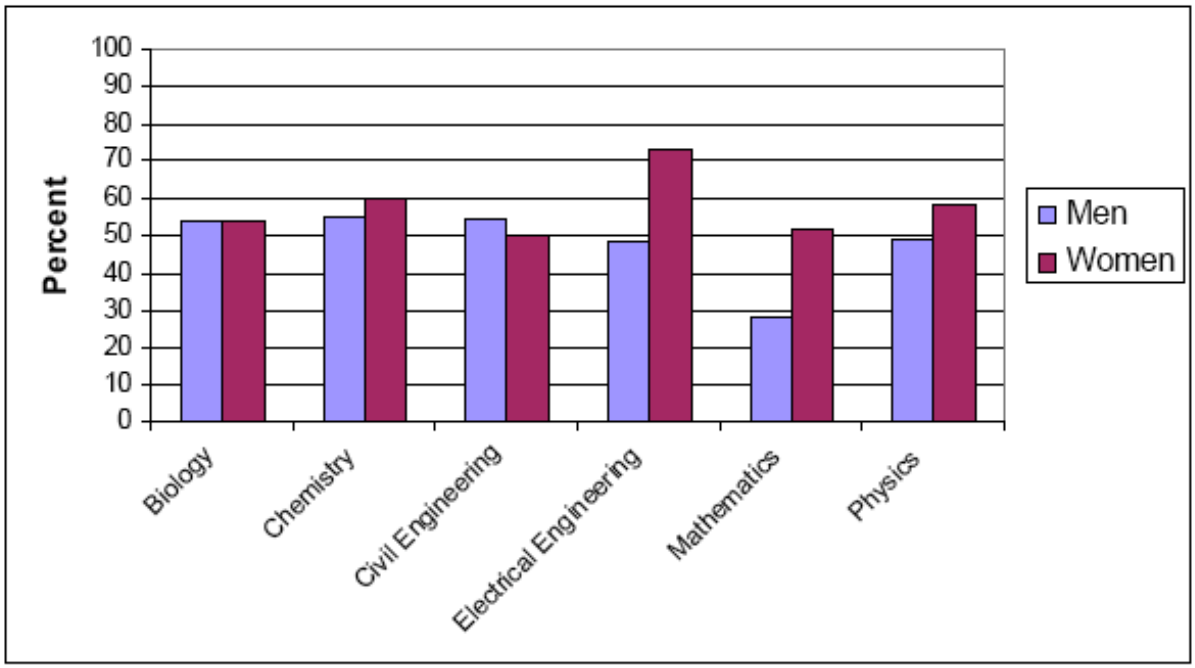


FIGURE 4-6 Percent of faculty responding that they had a mentor, by gender and field.

STEM-A (Science, Technology, Engineering and Math through Art)
STEM+ART=MATTERS

Why choose to use Art as a form of teaching STEM? According to David Warlick, "the creative arts are the language of the 21st Century." As many students today use technology and media as a source for almost all their stimulating interactions, it is logical for educators to look for solution in teaching methods using technology and social networking which students are accustomed to.

Art curicullium has the ability to teach ethics along with STEM basics, allowing for development in "21st Century Citizenry." In addition, use of inventive behavior is encouraged, while techniques are allowed to be developed through practice of creative exploration. The integreation of STEM and ART allows for the students who may not have been interested in a STEM track, an opportunity to explore an alternative way of approaching STEM education.

We have to move past the social stigmas which place "white males", "geeks," and the "socially isolated" as our only genuises or our "key science role leaders". We need to diversify our beliefs, and start thinking of ourselves as human, with a variety of capibilities, not limited to our ethnicity, sex, religion, or social and parental status.

"For whatever reason, women are still underrepresented in mission leadership at NASA. It would serve the community well to understand the reasons for this, to be sure that needed leadership and

talent are not being overlooked when selecting teams to plan and execute the challenging space science missions proposed in years to come. Exploration of the Solar System is a task that requires the very best scientists, engineers, and managers, regardless of gender."

The YK10 budget for NASA, includes only 7%, 126.1 million dollars, of the total 18 billion dollar proposed budget toward education.

Recently Presidnet Obama addressed issues of STEM education in his address to the public in a document called, A new era of responsibility.

> To give our children a fair shot to thrive in a global, information-age economy, we will equip thousands of schools, community colleges, and universities with 21st Century classrooms, labs, and libraries. We'll provide new technology and new training for teachers so that students in Chicago and Boston can compete with kids in Beijing for the high-tech, high-wage jobs of the future. We will invest in innovation, and open the doors of college to millions of students. We will pursue new reforms—lifting standards in our schools and recruiting, training, and rewarding a new generation of teachers. And in an era of skyrocketing college tuitions, we will make sure that the doors of college remain open to children from all walks of life.

As the presidents mission sounds great, the facts are that education of our nations children, our future entroponures and inventors, is falling behind our international competitors. We have the largest national debt ever, and it's parcially because we consume more technology than any other country. We are short-changing our future, by not funding the education of our youth and non-traditional learners more. The dficite in STEM education is really a problem of societal determinism through mico-inequities of non-traditional lerners. Addressing this issue is key for the future of NASA as well as American national security and pride.

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