Research Methodologies in Science Education: Gender and the Geosciences

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Allison, a postdoc in structural geology, is in the process of applying and interviewing for jobs. She and a number of her graduate school friends, both men and women, are also applying for jobs, and meet up at the Geological Society of America annual meeting to discuss their experiences. Much to her surprise, Allison finds out that her friends have had similar experiences, learning that most geology departments have few or no female faculty. Allison suddenly finds herself reflecting on herself as a woman in science, something that never seemed particularly important before. She realizes that although she went to a small liberal arts college, she only had one female instructor as an undergraduate (and not in science), and actually never had a female instructor in graduate school. Looking back, Allison realizes that only 10% of the geology faculty in graduate school were women, although it seemed like half of her fellow graduate students were women. Suddenly, Allison begins to wonder why so few women are geoscience faculty, and if her gender will affect her chances of landing a faculty position.

MYTHS OR REALITY IN GENDER DISCUSSIONS

What are the realities of being a woman in science in the 21st century? What are the common beliefs held by the community at large, and how do these beliefs about gender reflect reality? During a recent symposium on women in science convened by Radcliffe (http://www.hcs.harvard.edu/~wishr/), a number of stereotypes about gender peppered the conversation, often with an assumption of the truthfulness of these statements. Four ideas dominated the discussion, primarily that:

1. Women have low confidence: One speaker stated, “Women aren’t as confident as men”.
2. Women are more modest than men: The comment, “Women don’t like to talk about their accomplishments”, cropped up again and again.
3. Women are less productive than men because women are perfectionists: One speaker stated, “Men are eager to publish results; women take too long trying to make a study perfect”.
4. Women prefer to cooperate rather than compete: One speaker stated, “Women prefer to cooperate, while men are more amenable to science’s competitive environment”.

Interestingly, the female speakers making these statements attributed them to other women, *not* themselves, and saw themselves as “outside the norm”. This column will assess the literature on gender, gender differences, and science to 1) address the veracity of these ideas and 2) look at the issues that may be influencing the gender inequity that still exists in many science and engineering fields.

IS THIS A PROBLEM? DO WE NEED A SOLUTION?

Why has so much time and energy been spent on issues related to diversity? The recent Supreme Court decision related to affirmative action at the University of Michigan suggests that diversity is *a priori* a desired state, and that diversity itself enriches the learning process. Although there are diverse views about the inherent value of diversity, some have suggested that an inclusive attitude broadens perspective, allowing new ideas to evolve, and strengthens and invigorates the overall productivity of a discipline. In simpler terms, a lack of diversity suggests that an environment may be hostile to some groups, prohibiting perhaps the most talented members of society, regardless of demographic factors, from intellectually enriching that environment. With respect to gender, any field that is unwelcoming to either men or women is limiting fully half of the workforce from participating, creating a situation that is wasteful of potential.

In the sciences, attention to demographic changes over time and research studies have shown that the gender gap increases at higher education levels. Discussed in more detail below, it is clear that in the physical sciences, including Earth, Atmospheric, and Ocean Sciences, women are less likely to complete graduate degrees than men, and even less likely to continue in certain careers, particularly in academia. The immense costs associated with training a highly specialized (Ph.D.) scientist, as well as the large amount of time spent pursuing this training, on the part of the student, faculty, and institutions, alone suggests that this is an untenable situation. Certainly, the monetary and time costs of educating scientists creates a desire that no individuals leave the field, and if one group appears to be leaving at higher rates than others (e.g. women) then it is worthwhile to explore whether or not this trend indeed exists and which factors may be related to attrition.

CHANGING DEMOGRAPHICS OF SCIENCE

Before the 20th century, women rarely were able to work towards degrees in science and engineering, nor even work in these fields as non-degree personnel (Holloway 1993, Li 2002). Notable exceptions exist, particularly in the late 1900s, such as Marie Curie, a nuclear physicist, and Annie Jump Cannon, a pioneering astronomer at the Harvard Observatory, among others. Beginning in the 1960s, however, women began to major in non-traditional fields, with a steady increase in the number of women receiving B.S. degrees in science and engineering; today half of all such degrees go to women

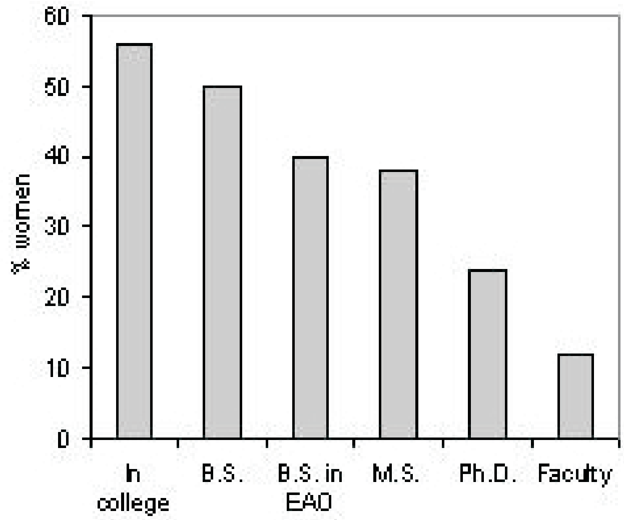

Figure 1. Percentage of women at various stages of academic careers. Women make up more than 50% of college attendees and B.S. degrees in science are awarded equally to men and women. However, only 30% of Ph.D.s in Earth, Ocean, and Atmospheric Sciences were awarded to women, and women comprise only 12% of the working Ph.D. labor force in EAO. (Long et al., 2001)

(NSF, 2000). Of interest to gender researchers is a phenomenon known as the "leaky pipeline" – while undergraduate women are majoring in science and engineering in equal numbers to men, their graduate school counterparts are not. Indeed, although half of all science and engineering B.S. degrees go to women, only 34% of Ph.D.s in science and engineering are awarded to women. Where have all the women gone, and why?

Interestingly, more women attend college than men; in 1996 about 56% of all undergraduates in the U.S. were women. In addition, more women receive high school degrees than men, and women generally thrive in the K-12 environment (Sommers, 2000). In the end, elementary and secondary education is welcoming to both men and women, and some argument could be made that it is more welcoming to women. However, at the postsecondary level and beyond –graduate school and jobs in academia and industry– the sub-disciplines of science and engineering, particularly in non-biology related fields, attract many more men than women, and research suggests that these fields may be inadvertently or intentionally hostile to women.

Several prominent national studies provide some insights into the changing demographics of science, in particular studies carried out by the National Science Foundation (NSF, 2000) and the National Academy of Sciences (Long et al., 2001) . These longitudinal studies track people across the educational and employment landscape, allowing a look at the trends in education and career choices made by different groups over time.

K-12

A number of studies have been published that compare the performance of males and females on achievement tests, and these studies generally find that males outperform females on math and science related tests in elementary through high school (Beller and Gafni, 1996; Campbell et al., 2000). In addition, boys tend to be more confident about their math and science abilities compared to girls, regardless of actual achievement (Debacker and Nelson, 2000).

UNDERGRADUATES

Nearly 56% of all undergraduates in the U.S. are women, and 50% of all science and engineering B.S. degrees go to women. Overall, a gender gap does not exist at the undergraduate level (Figure 1). However, women in science tend to focus on biological sciences. In the Earth, Atmosphere, and Ocean Sciences (EAO), only 40% of B.S. degrees in 2000 were awarded to women, a significant increase from 30% in 1991. These trends suggest that by 2009, B.S. degrees in EAO fields should be awarded equally across gender.

GRADUATE SCHOOL

Many studies focus on attrition rates in graduate school as an important nexus for the gender gap, and refer to this attrition as the "leaky pipeline". In particular, while 38% of M.S. degrees in EAO were awarded to women in 2000, indistinguishable from the B.S. rate, only 31% of Ph.D.s in EAO went to women in 2000 (Figure 1). Although a lag time does exist between acquisition of a B.S. degree and completion of graduate school, 31% still represents a loss of female participants. For example, assuming 5 years to complete a Ph.D., one would expect to see roughly 38% of all EAO Ph.D.s going to women in 2000. Researchers have sought to answer the question of why women are either not entering Ph.D. programs or are not completing Ph.D. degrees. Additionally, a similar gender disparity exists in the workforce, particularly in academia.

ACADEMIA AND OTHER JOBS IN SCIENCE

Regardless of occupation, whether in academia or another scientific job, a significant gender disparity in the scientific workforce exists. In 1973, only about 7% of the full-time scientific workforce were women. This number increased to 20% in 1995, although workforce demographics vary widely by field (Long, 2001). This variability is almost exactly mirrored by the gender distribution observed in academia.

Overall, and across disciplines, a gender disparity in academia exists. In the geosciences, about 12% of all full-time working Ph.D.s are women, although nearly 40% of geosciences departments have no women faculty (Long et al., 2001; de Wet, et al., 2002, Figure 1). In 1995, the physical sciences had roughly 37,000 academic faculty nationwide, and about 4,000 of these faculty were women, a rate of only 11% (Long, 2001). Similar gender disparities exist for mathematics and engineering, where only 12% and 6% of all academic faculty are women, respectively. In both biology and the social and behavioral sciences, the gender disparity is much smaller, where about 30% of academic faculty are women.

THEORIES ABOUT THE CAUSES OF THE GENDER DISPARITY

Two theories proposed to account for gender inequity in the geosciences, and particularly in the academic workforce, dominate the discussion: the so-called "Glass Ceiling" and the tension between career and family obligations. In addition, several research studies have shown an interesting bias that occurs in hiring decisions that we will call "Accidental Bias".

I. GLASS CEILING

Most people have heard of the "Glass Ceiling", an artificial, invisible barrier that keeps people from advancing within an organization solely because of gender, ethnicity, or other characteristic. In fact, the U.S. government has its own Glass Ceiling Commission designed to remove these barriers. The theory of the Glass Ceiling builds on this, referring specifically to the artificial and systematic acculturation that affects every individual across his or her lifespan. According to the theory, for women, this acculturation translates into a pattern of discrimination that results in an inability to succeed fully in traditionally male-dominated fields. Over the course of a woman's life, thousands of small interactions will compile to produce the observed inequities, such as the gender disparity in EAO academic positions.

Proponents of this theory point out that girls are generally taught to "be nice" rather than aggressive and are expected to be compliant, especially when interacting with authority figures. Boys, on the other hand, are taught to be assertive and decisive. These societal expectations translate to women who are perceived as lacking confidence, who tend to be modest with respect to their accomplishments, and generally place more emphasis on perfectionism than men.

In a recent study, researchers found that parents themselves have a significant influence on the interests and self-efficacy of students (Tenenbaum and Leaper, 2003). Fifty 11 to 13 year-old students were observed interacting with their parents on a set of science tasks. The analysis of these interactions suggests that parents believe that science is more difficult for girls than boys and are more likely to believe that science is uninteresting to girls. A strong correlation was found between parents' beliefs and children's interest and self-efficacy in science, seemingly supporting the theory of the Glass Ceiling and the negative acculturation of girls with respect to science.

Although blatant gender discrimination in academic science is less common than in the past, subtle biases are still present (Holloway 1993, Sonnert 1995, Long et. al. 2001). In one study that followed the later career paths of a group of men and women who had received prestigious postdoctoral fellowships in the sciences, 41% of the males in the study held the rank of full professor while only 23% of the women did, even though the average professional age was similar (Sonnert 1995). Furthermore, there were differences between scientific disciplines; for example, among biologists, women scientists did as well as their male counterparts, in terms of academic rank and publications. But among the physical sciences, mathematics, and engineering, the women's academic status was usually one full rank below the men's (Sonnert 1995). Some of the women in the study reported a few cases of flagrant discrimination, but most reported more subtle obstacles such as: advisors treated female postdoctoral fellows as subordinates and male fellows as colleagues, and many women reported "feeling left out" – e.g., their colleagues or superiors didn't talk to women as often or ask them for input (Sonnert 1995). Sonnert (1995) suggests that the "glass ceiling" metaphor may be inappropriate, as many women scientists did not describe well-defined (albeit invisible) barriers, but rather many small incremental obstacles that tend to hinder careers. Holloway (1993) also makes the case that many small obstacles may slow female scientist's careers and the nature of the obstacles varies among individual cases.

Let's return to the four statements that predominated the discussion at the symposium on women in science at Radcliffe that we mentioned earlier:

1. Do women have lower confidence? It is extremely difficult to make such gross generalizations (and this applies to statements 2 to 4 also). However, there is some research, mainly from psychology and sociology, which suggests that women's perceptions of self are primarily rooted in their relationships with other people, *i.e.*, women have "extrinsic" self-worth. While we both know female scientists that do not fit this categorization, there seems to be some research that at least some women do have extrinsic self-worth. For example, in a study that looked at the factors that cause undergraduates to leave science, math, and engineering majors, Seymour and Hewitt (1997) found that female undergraduates felt alienated by male peers in their science classrooms and faculty in their introductory courses did not intervene to ameliorate this situation. Even though many of these women had high grades, many simply felt they were "not good enough" and switched out of science majors. Seymour and Hewitt (1997) conclude that the women were experiencing hostility and alienation from their male peers and were seeking reassurance and encouragement from faculty in their science courses. Because the faculty did not provide the needed reassurance or encouragement, these women believed that they were inadequate and chose to switch out of science, math, and engineering. There were several interviews where undergraduate women conveyed the belief that they were not capable of completing a science, math, or engineering degree when they receive just one bad exam grade. Women tend to be less confident of their performance, even when others judge their intellectual abilities and accomplishments to be impressive. Sonnert's (1995) study of a group of men and women who had held prestigious postdoctoral fellowships found that even at the late stages of their careers, these successful women had "slightly, but noticeably lower estimation of self confidence and ambition" than their male peers.

2. Are women more modest about their qualifications and achievements? Seymour and Hewitt (1997) found that men at the lower end of the achievement distribution are more likely than their female counterparts to continue to study math; women with good grades in math often question their abilities and often switch out of science majors. Again, these authors explain this finding as women having extrinsic self-worth and men having intrinsic self-worth. Modesty may prohibit women from understanding their own potential and it may translate into poor long range career planning (Brown et al. 1998). Even the successful women scientists in Sonnert's study

(1995) were perceived as less self-promoting than their male counterparts. It may be that women and men's styles of promoting their scientific work are simply different, but lack of self-promotion, taken to be modesty or self-doubt about their research accomplishments, may slow women's careers (Holloway 1993).

3. Do women display lower productivity? Past research has suggested that women are less productive than men, with several studies showing a gap in publication rates between men and women (Xie and Shauman, 1998, and references therein). Indeed, if data is taken at face value, female scientists are less productive than men, both in research dollars acquired and publications. However, recent reanalyses of these data indicate that the productivity gap is non-existent when the data are controlled for external variables (Xie and Shauman, 1998). In particular, if age, field and type of academic employment are controlled for in the analysis, the gender gap ceases to exist. As discussed above, women are more likely to be in non-math related fields, creating a publication gap because of the low number of women publishing theoretical papers. Additionally, women are more likely to have increased teaching duties relative to men, which also creates a "gap" in publications. Interestingly, Sonnert (1995) found that among biologists in their study (that followed a group of men and women who held prestigious postdoctoral fellowships in their later career paths), the women tended to do more comprehensive and synthetic work and that these women tended to receive more citations per article published than the men. Based on these studies, we suggest that women and men are equally productive, but the meaning of productivity in academia, traditionally limited to numbers of publications and grants may need to change to include quality of research, teaching, as well as service accomplishments.

4. Do women prefer to cooperate rather than compete? There is some suggestion that women may create a "niche" rather than compete in a "hot" area of research. Sonnert (1995) found that many women preferred to carve out their own area of expertise rather than race to solve the "hot" problem. Women and men also differed in how they characterized "good scientific work". Sonnert (1995) found that 36% of the women interviewed mentioned that good scientific work had to be thorough or comprehensive compared to 20% of the men; conversely, 43% of the men felt creativity or originality are characteristics of good research whereas only 30% of the women mentioned these characteristics. There are also some anecdotal comments in the literature that suggest women may manage research labs differently than men, but this difference as well as the differences in approaches to scientific research require further study.

Three additional misconceptions about gender bias are prevalent: (1) the assumption that gender discrimination requires a conscious attempt to discriminate against women or a sexist ideology; (2) the assumption that while gender discrimination may be found at other institutions or departments, it is not a factor in "my department or college/university"; (3) the assumption that although gender bias may be present, it's effects are so small as to be negligible. The 1999 self-study by MIT (that is being replicated at other institutions– see "Directions for Research" section) found that women scientists had less lab space, less recognition, fewer leadership roles, and lower salaries than their male counterparts (Long et al. 2001 also found that salary disparities persist). There was no conscious effort to discriminate against women scientists at MIT, yet the disparities were there, and are likely to be at many other institutions both large and small. Similar studies should be conducted at other academic institutions because although it is very hard to discern gender bias in individual cases, aggregate analyses may reveal that it is operating. (Additional references relevant to these issues can be found at http://dynamic.uoregon.edu/~jjf/ chillyclimate.html.)

II. FAMILY VS. CAREER

A number of researchers have suggested that the conflict between raising a family and having an academic career results in significant numbers of women leaving science, particularly prior to obtaining academic positions, or before tenure decisions are made. Two issues seem to be paramount for academic women in all areas, not simply the sciences: the two-career couple, or the "two-body problem" coined in physics, and the issue of having children and maintaining a career.

A recent analysis of post-graduation data indicates that there is a strong correlation between marriage, parenthood, and post-graduate degree attainment for women, but not for men (Clune et al., 2001). In particular, both men and women who married before receiving a bachelor's degree were less likely to enroll in graduate school than unmarried counterparts. However, post-graduation marriage or parenthood did not affect male enrollment or attainment of post-graduate degrees for men. For women, enrollment in doctoral or professional programs is much less likely for women who become parents after college graduation. These data suggest that parenthood and professional careers are not likely choices for women in many fields.

THE TWO-BODY PROBLEM

The two-body problem in physics refers to the equations of motion of two objects in mutual orbit. Physicists studying the issue of gender equity in science borrowed this term to refer to the problem faced by dual career couples, particularly in academia. Certainly, two career couples in any discipline are faced with more difficulty than single job seekers, particularly when finding jobs for both partners is a high priority. In academia, the scarcity of available jobs, the almost universal requirement of geographic relocation, and the low probability of finding two academic positions in the necessary fields in the same place makes dual career families particularly untenable. Academic scientists are then faced with three options: 1) Remain unattached; 2) Marry someone with a flexible career; or 3) Marry another academic or career-oriented individual and encounter the two-body problem! Interestingly, women are much more likely to have a two-body problem than men.

A recent study indicates that while 82% of academic men are married, only 62% of academic women are married (Mason and Goulden, 2002). This suggests that either academic women are choosing to remain unattached or that the process of acquiring and maintaining an academic position is not agreeable with marriage for women. In fact, data suggests that tenured women in science are twice as likely to be single than

Age (years)	Career Path	Children
18	Graduate High School	
22	Graduate College (4 years)	Men and women with pre-bachelor's marriage or babies are less likely to achieve higher degrees
27-30	Finish Graduate School (5-8 years)	Women with pre-tenure babies are less likely to achieve tenure than male counterparts
27-33	Post-Doc (1-3 years)	
28-35	Begin faculty position	Genetic defects of post-35 pregnancies increase to 1:270 and delivery via Cesarean section is more likely after age 35
35-40	Tenure Review at 6th year	One-third of women are infertile by 40 and one-third of all post-40 pregnancies end in miscarriage

Table 1. Milestones in path towards tenure and social and biological influences on mixing children and an academic career.

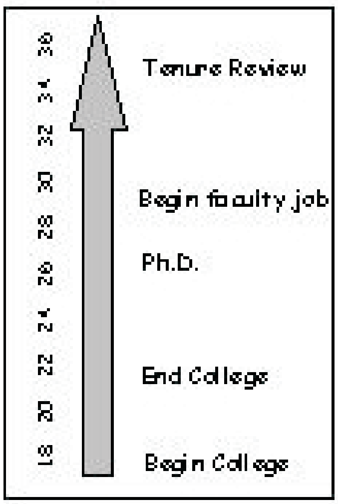

Figure 2. Timeline for acquisition of tenure. This timeline actually represents the shortest amount of time required to achieve tenure, from matriculation into college through tenure review. Notice that age 36 is likely the earliest start of post-tenure life (and for many people tenure will come later), just when biological factors begin to affect child bearing.

tenured men. Overall, about 35% of married academic men, regardless of discipline, are married to other academics, and this number rises only slightly, to 40%, for married academic women. However, in the sciences, anywhere from 50-70% of academic women are married to academics. This suggests that women are more likely to be faced with a two-body problem when seeking academic employment in science and engineering fields (Mason and Goulden, 2002).

In a recent study of young physicists in the job market, McNeil and Sher (1999) found that only about 20% of young, married male physicists were married to academics. On the other hand, nearly 70% of married female physicists were married to academics. Even accounting for unmarried women, nearly one-third of the female physicists polled faced an academic two-body problem! For institutions seeking to diversify the demographic makeup of their institutions, this is a significant stumbling block to hiring women.

A number of solutions to the two-body problem in academia have been suggested, although none of these is perfect, especially given the different desires of institutions, hiring departments, and individuals. In addition, institutions have to face a trade-off between limited resources and the happiness, and by implication, the productivity of their faculty. Wolf-Wendell, et al., 2003 offer a discussion of the various solutions available to two-career seekers. These solutions include:

1. External positions - Institutions may offer external job-placement services to spouses. In these cases a job for a spouse is rarely guaranteed. Alternatively, institutions in geographic proximity may co-advertise positions in the hopes of accommodating two-career couples. However, these institutions are still hiring independently, with little guarantee that a spousal pair will be hired.

2. Internal positions - Institutions may offer spouses of new hires in-house career opportunities. These are most often non-tenure track positions and may range anywhere from administrative positions to adjunct or part-time positions to fixed-term faculty positions. Rarely, tenure-track positions for spouses will be made available. Often these are positions are shared by both spouses (if they are in the same department), or are part-time tenure-track positions. Ultimately, institutions must keep both the happiness of new faculty and the financial stability of the institution in mind when making spousal-hiring decisions.

As with any case where a hiring decision is made on the basis of something other than qualifications, and this is certainly the case with spousal hires, several issues must be considered. First and foremost, institutions must weigh the issues of fairness and quality in the hiring decision, and ultimately decide if the spouse being hired is as qualified for the position as the new hire. Many institutions conducted additional interviews when seeking to hire spouses, as a method of quality control. Additionally, faculty are generally autonomous in hiring decisions, and typically make recommendations to institutions when it comes to the hiring of new faculty. Institutions must ensure that departments and individual faculty have a stake in the spousal hiring process (Wolf-Wendell et al., 2003).

CHILDREN AND ACADEMIA

Do children and academia mix? Research suggests that a gender gap exists here, as well, and that men are favored when it comes to having children and managing an academic career (Long et al. 2001, Mervis 2001, Mason and Goulden, 2002; de Wet et al., 2002). Two factors influence a woman's ability to participate in raising a family and managing an academic career: biological and social (Figure 2; Table 1). Biological influences are common knowledge: fertility decreases, and negative pregnancy outcomes and genetic defects increase for women as they near 40 years of age. Similarly, physical difficulties for pregnant women increase significantly after age 35 (de Wet et al., 2002). Comparing these biological factors to the "tenure timeline" (Figure 2) it becomes obvious that women who wait until after receipt of tenure are much more likely to face problems beginning a family.

It makes biological sense, then, for women to begin their families prior to acquiring tenure. Unfortunately, the very act of having children seems to reduce the likelihood that women will achieve tenure. Men in science who have babies pre-tenure are 24% more likely than their female counterparts to achieve tenure (Mason and Goulden, 2002). In fact, this finding holds true for the social sciences and humanities, where the gender gap in achieving tenure favors men by 20%. Indeed, women who hold academic positions are much less likely to have children than men, suggesting that either women are choosing not to have children in favor of their positions or academic positions favor women who choose not to have kids. These statistical findings are supported by qualitative studies, which find that women are concerned about the trade-offs between family and career.

Etzkowitz et al. (1994) interviewed faculty and graduate students in science and engineering departments at a research I institution. These researchers discovered that the majority of women interviewed planned to pursue careers in industry rather than academia, in particular because of the perception that academic jobs were less flexible than a "9 to 5" industry job. The majority of women looking for faculty positions were primarily interested in teaching positions as these were viewed as allowing the pursuit of non-career related interests, such as starting a family. Finally, many faculty expressed concerns about female graduate students having families, although these same concerns were not expressed with respect to male students. One female faculty member expressed her own anti-baby bias:

> "If a [prospective] student had a baby with her, I wouldn't have her. Students who have babies here get no work done. It's not that I wouldn't take a woman with a child in the first place, but the first sign of trouble, I would just tell them to go away. If my students fail it looks bad for me."

III. ACCIDENTAL BIAS

Sometimes people can inadvertently discriminate against someone based upon external factors unrelated to qualifications or productivity. An interesting effect related to gender and race exists in academia: both faculty and students are consistently biased against women and minorities without being aware of their own bias. We all this "accidental bias", and it has been observed in a number of settings. For example, Steinpres et al. (1999) used identical CVs with male and female names to study the effect of gender on hiring decisions. Overall, faculty were more likely to recommend the hiring of a job applicant with a male name over an applicant with a female name. Bias among college students also exists against female faculty. For example, students consistently rank papers with female authors lower than papers with male authors (Paludi and Bauer, 1983) and course evaluations for female faculty are generally lower than evaluations for male faculty (Basow, 1995). Additional references relevant to accidental bias and other issues can be found at http://dynamic.uoregon.edu/~jjf/chillyclimate.html.

IS THIS A PROBLEM? DO WE NEED A SOLUTION?

Several small changes in the academic environment would probably go a long way towards reducing the gender gap in the number of women completing higher education degrees in the geosciences and who continue on into academic faculty positions. In particular, the reduction of stress felt by new faculty would greatly alleviate many of the problems related to the family-career dichotomy, and would be a valuable change for all academic faculty, not just women. Holloway (1993) makes the comment that "universities are set up for men whose wives went with them" but times have changed. Based upon existing research and recommendations suggested therein, we would recommend that:

1. Funding agencies should lift age restrictions on career development grants because scientist's careers will develop at different rates for a variety of reasons. NSF has already changed their guidelines for the early CAREER grants.

2. Are rates of attrition for female graduate students higher in your department? Do a self-study. Do male graduate students get more RAs than female students? Long et al. 2001 found that male graduate students are more likely to get jobs as research assistants. Is this occurring in your department? Do a self-study. Do male and female scientists in your department/college/university get similar lab space and resources, recognition, leadership opportunities, and salaries? Do a self-study. If inequities are detected, acknowledge them and propose solutions.

3. Provide flexibility in the pre-tenure to tenure path. Reduce stress load of pre-tenure faculty by providing mentoring opportunities for new faculty and monitoring their progress. Provide flexibility in slowing tenure clock (by one semester to one year) to allow for child rearing.

4. Teach about teaching in graduate school so that new faculty are not overwhelmed by the demands of balancing research and teaching once they begin faculty positions.

5. Universities and colleges should provide access to quality childcare facilities and provide flexible work time and family-leave policies.

6. Be aware of the existence of "accidental bias" and guard against gender imbalances in hiring and promotion.

7. Make scientists and administrators aware of the social factors that determine scientific career outcomes.

DIRECTIONS FOR RESEARCH

MIT's self study in 1999 found that women faculty had less lab space, recognition, and leadership roles than their male counterparts. Lawler (2001) reports that the leaders of the top nine U.S. research universities agreed that barriers to women's careers do exist, that more data need to be collected, and they pledged to remove barriers at their institutions that hinder women's careers in science. Each university is conducting its own self-study. It would be useful for other universities and colleges to conduct similar self-studies to determine if gender bias or discrimination is occurring at their institution. Additionally, graduate programs should keep data on graduate students to determine if women tend to leave their program without completing their Ph.D.s at higher rates than male students and if there are inequities in distributions of research assistantships and other forms of recognition. It might be interesting for hiring committees to conduct their own blind reviews of applications. For example, committees could remove all mention of an applicant's name during the initial sweep of applications, to determine if gender of ethnicity affect who makes the first cut. Finally, the preliminary findings of Sonnert's study (1995) of women biologists' propensity to focus on synthetic research topics and produce publications that were cited more frequently than their male colleagues should be followed up. Are women's approaches and opinions of what constitutes "good work" really different and is this difference found in the physical sciences, mathematics, and/or engineering?

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