

Women and Science : No Community Support For a Culture of Success

Paula Rayman, Alice A. Oberfield, Anna Amundsen

Wellesley College Center for Research on Women
Wellesley, MA

The issue of women's attachment to science is not a new question. Over two centuries ago, when modern science was just emerging, Voltaire suggested that women lacked the capabilities to create "things mechanical, gunpowder, printing, and the clock." (1) Though, as Londa Schiebinger has documented, women were very involved as scholars and craftswomen during the early days of botany, astronomy, physics, and chemistry they were almost entirely excluded from membership in the growing number of scientific institutions. For example, since its inception in 1780, the Academy of Sciences in Berlin has admitted only 14 women among its 2900 members, with only four having full membership. (2)

More recently, Betty Uetter has reported that in the 1980's women's participation in the fields of mathematics and computer sciences was dropping even when the demand for personnel in those areas was increasing. (3) Throughout the lifespan, beginning with primary school education and continuing into the high school, college, graduate school, and career years females find themselves outside of the "culture of success" for science and engineering.

Why is this so? Previous studies have found several factors which prevent women's attachment and retention in the sciences: e.g. the lack of mentoring, adverse classroom environments, ineffective teaching methods and sex discrimination. (4) Each of these has been cited as playing a role in discouraging female science attachment at the various decision making points critical for producing women scientists.

While the majority of studies have focused on the elementary, high school and graduate school years, relatively few have been specifically concerned with young women's experiences at the undergraduate level. This paper reports findings from a longitudinal study of concentration choice at a major research university which allows a comparison of male and female undergraduate students. It is hoped these findings will deepen the understanding of how young women are discouraged from becoming scientists.

In addition, this paper would like at the onset to raise another question. During the last decade many national task forces have identified factors which limit women's success in science and have put out the call for programmatic action aimed at trying to rectify the situation: innovative teaching approaches, mentoring programs, targeting resources for new curriculum, and changing images of who is a scientist. (5) These have, in fact, been implemented in quite a few educational settings over the last decade. Why then, knowing what we do know and even having some programs that do respond to the call for change, have we progressed so little? The findings in this paper suggest that there is a fundamental difference between programmatic intervention and institutional change. What seems necessary is the creation of a community of support on an institutional scale in order to sustain a culture of success for women in science.

DESCRIPTION: CONCENTRATION CHOICE STUDY¹

The Concentration Choice Study looked at differences between the sexes in choosing a major and particularly, at women with a high level of ability and interest in science who do not choose science as a concentration. Participants in the study, chosen from the incoming class of 1983 included 150 men and 150 women of whom a total of 234 replied (N=234; 116 women, 118 men). Students were selected on the basis of an expressed intention to major in science or mathematics on their college applications, and included the physical sciences, biological sciences, mathematics, computer science, engineering and premedical studies. During the summer prior to matriculation and once each year during college these students completed questionnaires requesting information on their personal backgrounds, college experiences, choice of concentration and plans for a career. In addition, a subsample of 20 women and 20 men participated in yearly interviews designed to explore aspects of concentration choice, academic experiences and career plans in more depth.

Men and women were equally predisposed towards a scientific major and were comparable in the level of aptitude they possessed (nearly equivalent mean SAT scores: math -660 men and women, verbal -630 women, -610 men). Of the 40 students who were interviewed, 17 of the women and 15 of the men completed all four interviews.

RESULTS: SURVEY DATA

The students received a questionnaire prior to their entrance into college, in November of their freshman year, and in their sophomore year. Students were chosen by their intention to major in a science or mathematics field. (6)

Concentration Choice and Quality of Advising

When this cohort initially filled out the survey forms, there were no significant differences between the intended majors of men and women. There were also no differences in expected grade point averages, or anticipated graduate degree. Women enter the university with confidence in their abilities. By November, when concentration was first declared, still no differences occurred between men and women. In fact, 83.8% of the women said they were majoring in all or some science, while only 78.5% of the men indicated the same. Men appeared more confident about their choice of major. 38.9% of men said they were "very sure" about their concentration, and only 27.8% were "uncertain" about this choice. In comparison, only 19.8% of women were "very sure", and 48.5% of the women were uncertain about their choice of major.

By junior year, women have dropped from the science fields in significant numbers. While results are somewhat inconclusive due to the number of missing cases, only 44.4% of the women are concentrating in a science field, compared to 61.6% of the men. It is worth noting that both sexes tend to leave science, although women do so at a faster rate.

Examining the quantitative data concerning academic support exposes some of the differences which occur between men and women. Men (21.4%) were twice as likely as women (10.2%) to say that their advisor was helpful. Women also felt somewhat more discouraged by their advisors than men did, but not by a significant amount. However, men indicated that they received positive acknowledgement more often from academic advisors than did women.

¹ The Concentration Choice Study was originally authored by Bailey, Burrell and Ware and the data is housed at the Murray Research Center, Radcliffe College, Cambridge, Ma. This secondary analysis of the data was supported by a grant to P. Rayman by the Murray Research Center.

These differences may be a result of the manner in which men and women use and identify their reasons for seeking advice. Men and women were about as likely to seek academic advice from an advisor. However, men more often sought career advice, or wanted to use the advisor as a sounding board. Women tended more often to seek advice for personal reasons (which may be equivalent to a sounding board).

Men and women expressed different concerns about their role in the classroom. Women (56.1%) were more likely than men (39.4%) to fear being wrong when speaking in class. Men (67.8%) were more likely than women (47.5%) to feel free to disagree with the professor, particularly in courses which were not part of their concentration. Women and men indicated they spoke about equally in class.

Although not statistically significant, women (67.0%) considered social science classes and the humanities their most enjoyable course, compared to 53.2% of the men. More men (46.8%) than women (30.5%) say that science or math is their most enjoyable course. It is noteworthy that in this group of primary science concentrators, less than half the sample enjoy the science and math courses over social sciences and humanities.

Family Background

The family is often looked to as an explanation for gender differences in concentration choice. For the sample, 37.1% had a father in a science field, 17.3% had a mother in science, and 8.1% of the sample had both parents in science. Having both parents in a science field is not a significant predictor of men or women being science majors when they enter college. This remains nonsignificant even into their junior year. There are only two significant factors concerning the occupation of parents: women who intend to have a science career when they first enter college are more likely to have a mother in a science field, and women who still have a science major by junior year are more likely to have a father in a science occupation. Mothers may exert more influence on career choice prior to college, while fathers may dominate when the daughter actually chooses a permanent field.

Balancing Work and Family

While parents' occupation may play a crucial but small role in women's concentration choice, the students' own plans for balancing work/family issues factor into career decisions. Due to limitations of the sample, it is unknown how many of the students had parents who worked while their children were growing up. About 65.1% of the sample had mothers who were working at the time the students entered college. Surprisingly, all students in the survey expressed traditional attitudes toward work/family issues, although there were marked gender differences. Women (14.8%) were significantly more likely than men (11.8%) to have work/family balancing as a primary concern in choosing a career, but women (53.0%) were also more likely than men (45.8%) to choose a demanding career as their primary consideration.

However, men and women had dramatically different opinions about the career of their future partner. Only 39.6% of men expected their partner to work full time, compared to 86.4% of the women. About 8% of the men and women anticipated no partner.

These traditional attitudes were further emphasized by feelings about the mother's role in the raising of children. Significant differences were found between men and women concerning whether the mother should work full time, part time, or not at all when the children were infants, ages 2-5, ages 6-12, and as teenagers. In each case, a much greater percentage of men thought the mother should not work, or should work part time, while women felt that mothers should be allowed to work either full or part time. Even with these gender differences, 61.1% of women still believed a mother should not work at all when her child is an infant, and this number decreased to only 30.9% when the child is between age 2-5.

These gender differences disappeared when the students were asked about the role of fathers, work, and children. Men and women expect fathers to work full

time when they have children. A small significant difference occurred about the role of fathers when the children are ages 6-12. Here, men (18.3%) were more likely than women (3.1%) to say they should work part time instead of full time. A few liberated fathers in the group!

These numbers emphasize the lack of realistic support for working women with small children among both genders.

RESULTS: INTERVIEW DATA

Parental Influence

Parents play a critical role in students' major and career choices. Even just by example they acquaint their children with the possibilities available in a certain field. The interview data showed that most students had some input from their parents (asked for or otherwise) in choosing their majors. This support, or lack of it, had much more of an effect on women interested in science than men.

Women with a parent in science chose to stay in science much more frequently than those with parents in different career fields. While having a father in science increases the chances for a young woman to stay in science having both parents in the sciences was even a greater predictor. Thus, a mother's occupational role is an emerging important factor for influencing a daughter's concentration choice. It seems that parents in science are more likely to encourage their daughters in science, and they provide that important role model and example which many women lack. One student, a physics major, is a rare example of a female who stayed in one of the hard sciences even though she's struggling with the material and classroom atmosphere. Because both her parents were scientists, math and science were emphasized in her home. Her parents expected that she stay in science, and she will stick with physics. Such vehement parental support for majoring in science is usually not experienced by women but much more commonly by men. This is definitely an important piece in the puzzle of why so many more men than women major in the sciences.

Women interested in science in the study reported getting a much less enthusiastic reaction from home about a career in science than the men. In terms of retention, women who stay in science are much more likely to have at least one parent in science than men who stay in science. One frustrated female student reported that her mother didn't understand why she wanted to take chemistry. Luckily she was told by a female chemistry teacher in high school that she "had a good mind for science." Encouraged that someone she respected thought she could succeed in science, she eventually majored in biochemistry.

Male students don't usually need a blatant push from parents to consider, or stay in, science. Science is, after all, an incredibly male dominated career field. Men in science usually said that they had parental support for their decision to major in science but didn't often treat it as a factor in that decision. They discounted the importance of the parental, and societal, encouragement in science they had received their whole lives.

Of the men and women science majors, women were more likely to follow closely, or exactly, in their fathers' footsteps. More women who were pre-med had parents who were doctors while more men wanted to be in different science fields than their fathers. Representative cases are, for example, a male student, whose father is an engineer, who plans to be a doctor, and one whose father is a hospital administrator wants to get Md- PhD degrees. Women, on the other hand, when presented with the role model of a parent in science tend to deviate less from this example.

Introductory Course

Introductory science courses form a critical experience for students interested in majoring in science. They are the students' first contact with college science, though not always college level science. Unfortunately, nearly all interviewed students reported that these courses are blasts of frigid air in the face of their science ambitions. Men more often than women were able to make it through this

intimidating experience and continue to the more advanced, specialized and rewarding classes.

What makes the introductory science classes such a demoralizing experience for so many? Many intertwined factors contribute to create an atmosphere where few (compared to how many enrolled planning a science major) complete the major and fewer really thrive. Cut-throat competition between students is one of the most reported factors. It's a problem for students in all intro level science classes, but was especially noted by those in mathematics and chemistry. Female students find this type of classroom environment extremely difficult.

Students reported that often other students wouldn't help each other because a class was graded on a curve. Professors hardly seemed to care about their beginning level classes and were often disorganized and unclear. (7) Their disinterest in the classes contributed to making the material dull and difficult. Students who continued on in science revealed that they were able to feel that they could be "an active part in science" only in their upper level classes.

Most introductory science classes had hundreds of students and were split into sections with graduate students as leaders. As a result of the size of the classes there was little contact between the professor and individual students. This was a radical change from most students' high school experiences. Moreover many students were frustrated by section leaders who couldn't speak English or couldn't teach effectively.

The issue of sexual discrimination and harassment is an important one and has been relatively ignored in earlier studies. Problems were reported to occur in the classroom, during study sections, and when women went to seek advice. Women were sometimes harassed and propositioned by their section leaders and, especially as freshmen, didn't know where to turn. Women reported various forms of harassment. Professors sometimes made sexist jokes in class or on problem sets. Though they weren't directly asked about sexual harassment in their interviews, two women students said they had experienced or witnessed other females being propositioned repeatedly by male section leaders. One student was discouraged by the department from filing a formal complaint after she was harassed by a teaching assistant.

Many women felt lost in the crowd. Their professor would have no idea who they were if they went to office hours. Over 90% of women did ask their professors questions (a higher percentage than men) yet less than 10% could say that at least half of their professors gave them positive acknowledgement, compared to over 20% of men.

Students who entered their sciences classes with a specific career goal weathered the storm more often than those with a vague idea about what purpose the class would serve in the larger scheme of their lives. Their distinct purpose justified all the hard work and enduring of the introductory science atmosphere and sustained them when grades looked bleak. Tellingly, women were half as likely as men to enter college being fairly certain of the career they wanted to pursue. With a less clear set of options in front of them, women tended to decide that the intro science classes "weren't worth it" more often than men even though on average they had at least as good grades as the men. It wasn't that they couldn't do the work; it was that it wasn't all as enjoyable anymore. Why should they stay in an environment that didn't welcome them or support them?

Women were told that discrimination against women in science was a thing of the past. Yet women rarely or ever had a female professor or section leader to be a role model and to evidence the professed possibilities for women in science. Consequently, there was practically no support for them in the sciences or appreciation for the dilemmas between family, career and social expectations that they faced.

Differences Between Sciences

Though student experiences in the sciences were united by common themes such as the pre-med stereotype, the lack of effective, interested professors, and

intense competition students also reported differences between departments. Each science department had its own atmosphere and level of student retention.

The most popular department was biochemistry. Students disaffected by other science departments often switched to biochemistry, or biology, if they stayed in science, and relatively few who came wanting to do biochemistry switched out. One of the reasons students felt secure in this department was the one-on-one tutorial program. It allowed students to work closely with a science professional on an in-depth project. For many students, especially women, this personal attention was very important in helping them feel competent and at home with biochemistry. The tutor often became a valuable "general advisor on life" and a connection to 'the real world' of science.

Biology was almost as popular a major as biochemistry. Students majoring in biology who were especially happy with that choice usually had been involved in an independent project at some time. Feeling 'trapped' in a science major was a pressure that women felt more than men. Students seemed to feel less of this in biology and biochemistry than in majors such as physics, applied math, etc., and that is part of the reason more women, and men, stayed. They could be unsure of their future plans and not feel like they were locking themselves into something.

Most students who majored in biochemistry went on to medical school, yet the department wasn't characterized as stereotypically pre-med, i.e. stressful and ultra-competitive. The chemistry and physics departments, however, got more frustrated and angry reviews. Probably the most infamous course at was 'Chem 20.' Chem 10 sent quite a few freshmen packing, but Chem 20 was by far the class that most often drove students away from chemistry, or science in general. It was required by the pre-med program and many other majors, so the classes were large and fiercely competitive. The most non-negative comment the course received was that it was "annoying." More routine opinions were "cut-throat," "terrible" and "uncomfortable." The students found the professors intimidating, and the class was graded on a curve so that the students felt pitted against each other. With this class as an introduction to science, many students changed to a science major which didn't require more chemistry or left science altogether, which was the case for more women than men, in search of a setting where they could feel more important and at ease. Physics and chemistry students often noted a lack of role models for women.

The mathematics department got similar ratings in that students found the introductory level classes an unpleasant change from their high school experience. They also singled out an upper level course, Math 21, as especially unpleasant and discouraging. Some students switched majors to avoid the class or dropped the major after taking Math 21 because they no longer found math enjoyable. A student who had intended to major in math switched to an English major because she was supported in her efforts to improve in those courses and not in math. Math had always been her best subject, and she, along with many students, said what made it unenjoyable now was "the way it was presented".

Comparing Science and the Humanities

All students interviewed said they saw differences between science and non-science disciplines. Everyone agreed that a science major was generally a larger time commitment than non-science. Many students, especially women, were apprehensive about the sacrifice of other interests that majoring in science required. They worried about lacking broad knowledge and being "locked into science" by majoring in it. One student, like many who stayed in science, decided he was missing out on experimenting in different areas but that he could learn about them on his own more easily than the sciences. For women, this dilemma had another level. They also wondered how they could reconcile a science career with a family and traditional expectations of women.

Students generally saw a science major as more narrow and less flexible than the humanities and social sciences. They found no room for creativity in their introductory courses. An answer was right or it was wrong. To do well on tests, students had to memorize formulas rather than figure out why they worked. Women

students especially missed feeling that they could be an active part in science. Almost half the women who stayed in science even though they didn't enjoy it as much as other fields remained because they felt it was the best way to "make a difference" on a large scale. Men and women often reported they wanted to be in science to do something "worthwhile" on a level a career in another field couldn't match. They wanted to help people by becoming doctors or discovering new energy sources or new vaccines.

In their science classes they were thrown large amounts of information to remember, more often than not from a professor who wasn't helpful if they didn't understand the lecture. Their humanities classes, they said, were "interpretive" and open ended. Only a few found science, as it was presented, intuitive and individualized. There were more positive notes. For those who persevered through the crowded, competitive introductory level science classes the upper level courses were as experimental and undefined as any philosophy course. Many students enjoyed their science courses because of the solidity and logic they saw in them. Science was compared to a game by one student "that if you played by the rules, you got the right answer."

Usually science majors needed to 'get away' in some way from exclusively studying science. For some it was a battle between getting the best possible grades in science and feeling pigeon holed and isolated from the real world. Usually they regretted not being able to take more courses outside of the sciences, or not being able to spend enough time on those that they did take. They often joined sports teams, or did volunteer work, or were involved in other activities even though they weren't completely happy with their grades. A physics and philosophy major said he needed philosophy to give him "a perspective on science," and a biochemistry major enjoyed making films for the "unlogicalness" of it.

All students complained of the intense, hindering competition in some of their science classes. The classes required for pre-meds were "uncomfortable," "cut throat" and unenjoyable. Humanities teachers were more often helpful and caring, and there were no complaints of an unhealthy attitude or atmosphere in their non-science classes. The "science atmosphere" bothered women much more than men. They reported more intimidation by unfriendly professors and classmates. Even though their first year grades were usually at least as good or better than men's, women indicated more discouragement and a sense of less competency in their science classes.

Feeling At Home In Science

Science has always been an acceptable, often preferred, field for men to study. This exposes them to a complex bundle of social benefits called 'the culture of success' from which women have been side-lined. In opposition women are often victims of a 'culture of failure' that sets them up to feel insecure and inadequate, making it much harder to succeed.

It was harder for women than men to feel in control in science. Along with the pressure to get good grades in their science classes, women said they faced a "social pressure" to branch out from science. A female student complained that women are told they can do science, but are given no support when they try. A student might be the only woman in her class; at most she was in the minority. Women rarely if ever had female professors or teaching assistants in science to be examples and role models for success. One student said she felt "in limbo" because she wasn't a pioneer, as a woman, in her field, but she didn't have the anonymity that male students had either.

Overall, women tended to have a harder time feeling comfortable with a science major than men did. As seniors many women said that they finally understood how to "get things done" through the department or the general administration. More often than men, they worried about getting "burned out" and not continuing in science. They also grappled with how to fit in a career in science and a family. If they had the example of a relative, especially a father, in science they were much more

likely to continue in science while this affected men less or not at all because they had examples of success all around them.

Conclusion

This report on the findings from the Concentration Choice Study confirms previous research which demonstrated the fall-off of student attachment to science during the undergraduate years. Moreover, this paper documents that undergraduate women, with similar abilities and predisposition as their male counterparts, fall away from science at a significantly greater rate than undergraduate men.

Both the survey and interview data demonstrate that classroom environment does indeed play a role in discouraging young women's attachment to science, including factors which accentuate competition at the expense of building confidence. The findings suggest that both male and female undergraduates, even those showing a definite attraction to science, prefer their non-science courses. The absence of enjoying science is clearly an important factor which deserves consideration if more students are to be attracted and retained in science fields.

Finally the paper rises three factors which appear to play a significant role in women's science attachment that have received little attention and deserve further exploration: mother's occupational role, sexual harassment and work/family relations. Previous studies have commented on the significance of a father's occupation on a woman's career choices, but the relationship of mother's employment to her daughter's choice of major is an unexplored terrain in terms of science concentration. Findings from this paper suggest it may be an especially key ingredient during the early undergraduate years.

Sexual harassment is an issue which is rapidly gaining more attention on campuses across the nation. Especially from the interview data, it is clear it plays a part in setting the tone for actions inside and outside the science classroom, including actions by professors, graduate assistants, and possibly advisors. If science is to welcome more women this subject of sexual harassment needs careful and thorough investigation on the institutional level.

The third factor deserving more study is that of work/family dynamics and it too raises institutional formulations. Without major transformation of how work in science gets done to support family needs, women (and progressive men) will sense the culture of success is impossible to balance with family life. The data from this paper shows that traditional gender values remained strong for emerging young scientists during the 1980's. The question of how to produce a community of support for a culture of success that will embrace women students, thus, also remains.

NOTES

1. Quoted from Londa Schiebinger, The Mind Has No Sex, Harvard University Press, Cambridge MA, 1989.
2. Ibid p.100
3. Betty Vetter, "Women's Gain In Science" Mosaic, 18(1), p.2-9, 1987.
4. For example see studies by Zuckerman, H. and Cole, J. "Marriage, Motherhood and Research Performance in Science" Scientific American, 256(2), pp. 119-125, February, 1987; Abir-Am and Outran, D., "Uneasy Careers and Intimate Lives" in P.Abir and D. Outran(eds.), Women In Science, New Brunswick, New Jersey, Rutgers University Press, 1987 and Bruer, J.T. "Women In Science: Toward Equitable Participation", Science, Technology and Human Values, 9(3), pp.3-7, summer, 1984.
5. Among the more recent national task force reports which address the issue of women and science are :
The Task Force on Women, Minorities and the Handicapped in Science and Technology, "Changing America: The New Face of Science and Engineering", National Science Foundation, Washington D.C., 1988: and Math, Science Education Action Conference Report, U.S. Department of Energy, Washington D.C., May 1990.
6. Follow-ups were conducted for their junior and senior year. However, an elevated level of attrition prevented complete analysis of these last two years. Results from the survey were also limited by an incomplete codebook for the study. Crosstabs were computed on a number of variables, and level of significance was computed using Chi-Square. Despite the limitations of the data, the findings represent several points for thought about the barriers to women and science careers.
7. For a discussion of the issues of poor teaching methods and confusion see Sheila Tobias (ed.) They're Not Dumb. They're Different, Research Corporation, Arizona, 1990.

