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Factors Influencing Career Choice for Women
in Science, Mathematics, and Technology:
The Importance of a Transforming Experience

Leslie M. Besecke and Anne H. Reilly

Loyola University Chicago

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Abstract

Organizations in the business sector, as well as government and academia, continue to demand intelligent professionals trained in science, mathematics, and technology. This paper explores factors that may influence women's initial choices to pursue careers in these fields. In addition to the many well-established factors that guide an individual's career choice, we propose that women who choose careers in science and technology have a subset of common early experiences that encourage them to pursue a career path still regarded as contrary to traditional gender roles for women. For many women, this common background is a *transforming experience* that supports their career choice in science, mathematics, and technology. This transforming experience is composed of personal contact with a role model and often an intimate involvement with the process that serves as an invitation into the world of scientific inquiry. The researchers outline a model for women's career selection in these nontraditional fields, and our results suggest some recommendations for increasing the numbers of women in these careers.

Factors Influencing Career Choice for Women
in Science, Mathematics, and Technology:
The Importance of a Transforming Experience

"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology."
-- Carl Sagan, American Scientist, 1934-1996

Scientific and technological progress is one of the key engines upon which our economy and culture depend for the continually improving standard of living enjoyed by much of Western society. Whether leading to unprecedented space exploration, access to the human genome, or simply faster and better consumer products, scientific discoveries and the scientific method that drives them occupy a place of respect and importance in our society and in the marketplace. Similarly, those pursuing science as a career, including researchers, physicians, and engineers, have access to information that can make valuable differences in human lives. In addition, they often enjoy commensurate access to higher pay and higher standards of living associated with such careers (U.S. Department of Labor, 2004a). Unfortunately, equal participation in and contribution to careers in science by all those with the greatest ability and interest, regardless of gender or race, has not yet been achieved.

For decades, women have been greatly underrepresented in science, mathematics, and technology careers (National Science Foundation, 2003). Tables 1 and 2 present some selected summary statistics for degrees granted and annual earnings among the U.S. workforce for 2002, categorized by gender, field of study, and occupation. As these tables show, although women earn the majority of bachelor's and master's degrees granted in these fields overall (U.S. Department of Education, 2003), the number of women currently employed as natural scientists, engineers, and math and computer scientists remain a significant minority (National Science Foundation, 2003; U.S. Department of Labor, 2004b). In fact, the U.S. Department of Labor has defined these careers to be among those that are nontraditional choices for women. Furthermore, as Table 2 shows, women in these occupations, plus science technicians, earn less than men in every category. Table 1 also illustrates that the percentage of doctorates awarded to women is below 30% for computer and information scientists, engineers, mathematicians, and physical scientists and technicians, although these are among the fastest growing industries in the U.S. economy (U.S. Department of Labor, 2004b).

Proficiency and interest in the sciences are similar for boys and girls in the U.S. at age 9, but a significant gender gap begins to appear by age 13, as measured by mean scores on the NAEP mathematics assessment (U.S. Department of Education, 2000). By 12th grade, males consistently have more positive attitudes than females about mathematics and science (U.S. Department of Education, 2000). Turner and Bowen's 1999 study of college-age men and women concluded that a widening divide exists between the life sciences and math/physical science in terms of relative career attractiveness to men and women, in that women are actually slightly overrepresented in a survey of intended majors for incoming college freshman in the field of biology but are at least two to

threefold less interested in choosing engineering, computer sciences, or technical majors than were men. However, even in science fields where the number of bachelor's, master's, and doctoral degrees awarded has reached parity, such as biology (U.S. Department of Education, 2003), it is clear that increases in numbers of women beginning or completing scientific training are not translating into equality of long-term participation in scientific careers. Salaries for women graduates with science degrees are significantly lower than men with similar credentials (see Tables 1 and 2).

Individual female scientists, their employers, and the U.S. economy as a whole are all greatly affected by the under representation of women in science and technology related careers. On an individual basis, Table 2 illustrates that fewer women than men enter these high paying fields, and those women who do earn less than their male counterparts. A "leaking pipeline" metaphor (Hanson, 1996) is useful in describing the obstacles that work against women's persistence in science related careers, such as fewer job opportunities and the constraints of balancing career and family. From a more macro perspective, the underrepresentation of women in scientific and technological careers, coupled with the "leaking pipeline" out of those careers, means that organizations and the U.S. economy as a whole are unable to access the potential talent and skills of the female half of the general population. Simply put, companies are not maximizing their use of the available skilled labor pool. In an economic era characterized by ever-increasing competition, this gender inequity is a critical waste of financial and intellectual resources. Furthermore, the paucity of women's voices in these careers has allowed science to develop without the full input from all of human experience, and, as an institution, it suffers because of this.

The purpose of this study is to explore some key factors that influence women's initial career choices into scientific fields in the business, government, and academic sectors of employment. In particular, the role of early enriching experiences and mentoring relationships will be examined as a positive influence on women's selection and success in science, math, and technology (American Association of University Women, 2004; Norby, 1997). In addition to the many well-established factors that help to guide an individual's career choice, women who choose careers in scientific fields have a subset of common early experiences that encourage them to pursue a career path still regarded as contrary to traditional gender roles for women. For many women, these early events represent a *transforming experience* that introduces the girl or woman to science as an opportunity for her. This transforming experience is composed of personal contact with a mentor or role model and often an intimate involvement with the scientific process that serves as an invitation into the world of scientific inquiry. The researchers propose a model for women's career selection in these nontraditional fields and discuss the implications for increasing the numbers of women in science, mathematics, and technology careers.

Career Choices for Women in Science, Mathematics, and Technology

Efforts to understand the driving forces behind the underrepresentation of women in the sciences have considered a variety of factors that may impact career choice. For example, studies have examined gender differences relating to academic performance and preparation at the high school, college, and graduate levels (American Association of University Women, 1998; U.S. Department of Labor, 2004b) access to educational and career resources both in and outside the classroom (American Association of University Women, 2004), and retention of women interested in science careers while in the "leaking pipeline" (Brush, 1991; Hanson, 1996) during the training period and in their early jobs.

Significant social, personality, and social psychological differences have been identified for women pursuing traditional versus nontraditional careers for females. For example, Lemkau's (1983) comprehensive review of the personality and background of women in male-dominated occupations reports that these women have high levels of maternal employment and unusual opportunities to witness a wide range of male and female work models. Lemkau's respondents frequently report having been encouraged and supported in pursuing higher education and masculine as well as feminine endeavors. In a longitudinal study spanning ten years, Mills (1997) found that personality traits, when added to high mathematics ability, increased the probability that young women would pursue a career in science or mathematics.

Individual intelligence and academic proficiency are clearly associated with success in science, math, and technology fields (Mau, 2003; Mills, 1997; Nauta, Epperson, & Kahn, 1998). Women in science tend to be independent and emotionally stable with a high need for achievement and a high academic and social self-esteem (Lobel, Agami-Rozenblat, & Bempechat, 1993). Chatterjee and McCarrey's 1991 study presented data in which sex-role attitudes were examined in women in both sex-typical and non-sex-typical fields. Their data indicated a higher autonomy score and a less sex-typed self-concept in women in nontraditional fields.

According to Mortimer, Dennehy, and Lee (1992), parental education level had the most effect on the educational plans and occupational aspirations of adolescents. Lemkau's (1983) research suggests that women in nontraditional occupations have more frequently experienced family environments enriched by varied models in which they were stimulated to explore an unusually broad range of behaviors and career options. These women were more likely to report the positive influence of men, including fathers and male teachers, while women pursuing sex-typical careers reported more female influences, but this effect may be a reflection of the status of women in these careers at the time of Lemkau's work. Research by Norby (1997) suggests that having a family member employed in a science or technology-related career was an important factor in influencing women's career choices in these areas.

Scholarly publications and the popular press alike have argued for the importance of mentoring and hands-on experience as strategies for retaining women science, mathematics, and engineering majors (e.g., "Women in Science Say Mentors are Crucial," *Chicago Tribune*, Fitzgerald, 2002; "Balancing the Equation," National Council for Research on Women, 2001). Research by Ragins and Cotton (1999) found that protégés, especially females who are informally mentored, are more satisfied with their mentors, receive more career help, and enjoy more psychosocial benefits in terms of friendship, social support, role modeling, and acceptance.

The Transforming Experience

In this paper, we propose the importance of a *transforming experience* in encouraging girls and women to pursue careers in science and technology. We define this transforming experience broadly: important and path-setting interactions with role models and mentors, which can include individual intervention, counseling, laboratory projects, the opportunity to interact with scientists, and personal relationships. These transforming experiences have a dynamic role in fostering the confidence and perseverance necessary for girls to make and then act on their initial choice towards science or technology. For example, with the encouragement of a mentor a girl might be able to challenge family or personal gender stereotypes or surmount external obstacles, such as classroom harassment, to reach her goal of a career in science.

Method

The first author contacted 33 individuals employed across the United States and invited them to participate in this field study. The response rate was 91%, yielding a sample of 30 respondents aged 26 to 46 who are currently working in scientific fields. Twenty were women and 10 were men. Although a convenience sample, the respondents were chosen to maximize diversity. Thus, they included Ph.D.'s, master's, and bachelor's degreed scientists in different career stages employed in academic, industrial, and governmental sectors across various scientific disciplines. Ethnic backgrounds included the United States, India, South Africa, and China.

Table 3 summarizes the structured interview questions, which focused on having respondents recall how they were introduced to science and what influences they felt helped them choose science as a career. Over a three-month period, the first author conducted these individual interviews using an e-mail dialogue

format. On average, the e-mail dialogues lasted 30 minutes. The e-mail interview format allowed the researchers both to contact scientists across the United States and to allow the study participants to respond in a convenient format.

Printed e-mail texts provided transcriptions of these qualitative data. The first author analyzed the contents of the 30 transcripts, searching for shared key themes. The second author then compared a sample of the transcripts with the content analysis to check consistency in coding. The key themes identified in the interview transcripts are summarized in Table 4. While the ability to generalize from 30 respondents is of course limited, Table 4 illustrates some intriguing factors that appear to influence career choice in science and technology.

Results and Discussion

As Table 4 illustrates, the data identified three broad categories of career influences. First, the specific role that *families* play in encouraging women to pursue science education and science careers may be composed both of support for girls' interest in the sciences, but also the absence of discouragement for disciplines and careers that are nontraditional for girls and women. Second, innate *personality* variables and their expression, such as high need for achievement, play a part in influencing the choice of a scientific or technical career. Third, the importance of *transforming experiences* in affecting a science career choice, including interactions with role models, mentors, and individualized encouragement and counseling, was underscored throughout the e-mail dialogues.

Parental and family influence.

In general, women with careers in science reported very little direct parental influence in their choice of science as a career. In fact, most women suggested that their parents were supportive of them and their education in general, but that they did not do anything in particular to encourage or discourage science and math careers over any other. As one female professor of zoology reported, "They didn't play much of a role...neither went to college...they were just ecstatic I attended college. They don't understand what I do, but are extremely proud and supportive of my educational goals."

Although many researchers have linked early family influence to career choice, it is possible that what is actually important for girls pursuing science careers is the more generalized support from parents and the absence of gender-stereotyped discouragement that may be at the core of how families help foster interest in science and science careers (Norby, 1997). In contrast, all ten of the male scientists surveyed reported having a parent who was employed as a scientist and also being steered into science careers and away from others perceived as less financially rewarding.

Personality variables.

Our e-mail dialogues tended to support the personality variables reported in the literature as associated with women's career choice into scientific jobs (e.g., Mau, 2005; Mills, 1997). For example, a common theme that emerged was the high math/science proficiency coupled with the high need for achievement required for success as a scientist. One academic biologist noted, "I think this notion of science as a difficult field may keep girls from pursuing it. After all, there truly are easier (and more lucrative) ways to make a living." An endocrinologist reported, "I could work 20 hours a day seven days a week and there would still be things I don't understand or know. This can be frustrating and difficult given the many other demands on women's time and energy."

Several women respondents also noted the importance of strengthening academic and social self-esteem, especially given the perception of science as a non-traditional career choice for women (Lobel et al., 1993). According to one woman doctor in our sample, "I think girls need to receive more positive encouragement in very specific ways. Lack of confidence is a major obstacle. The notion that boys are better with laboratory equipment is also damaging to girls." An academic researcher commented,

In retrospect, I was not confident about my intellect or abilities, but I was always an excellent student. Now I know this is a common experience for a girl, especially in adolescence. At the time, however, it didn't occur to me that I was bright and capable of pursuing any of a number of career options.

Role model influence and enriching experiences.

The data supported the importance of a role model/mentor and an enriching experience sometime in high school or college (Nauta et al., 1998). In general, men recalled being talented and interested in nature and science courses; a career in that field, according to a male engineer, "naturally followed." In contrast, 17 of the 20 women respondents were able to name key teachers and professors as well as detail the specifics of their interactions, which included independent study opportunities, individualized encouragement, and counseling. The women all attributed their science preparation, interest in science, and career aspirations to these interactions. A female biomedical researcher noted, "It was my undergraduate advisor, Dr. S....She was so supportive and demanding and the first person to suggest to me I might have a special aptitude."

These results support earlier research emphasizing the importance of individual mentoring experiences between teacher and student in the sciences (American Association of University Women, 2004).

The Case for the Importance of a Transforming Experience

These reported differences between women's and men's career choice influences may, in part, be due to recall and reporting differences, since it is likely that men had similar opportunities for mentoring and independent study. What seems clear is that for women, these interactions were important enough to serve as a *transforming experience* for them as they were choosing careers. The detail and language used in describing these interactions are vivid and concrete, even decades later. One woman physician recalled,

I had a science teacher *in grade school* (italics added) who made science fun...he staged a rubber band fight in the class, explaining that when a rubber band was drawn and ready to shoot it had potential energy...when it was released, that potential energy was converted to kinetic energy.

The fact that in many cases the mentoring relationships continue to the present also underscores the relative importance these happenings have for these women. According to a female medical researcher,

I worked in Beth D's lab as a college senior...and unconsciously I clung to her because the mere presence of a successful woman in science was a novel image in my experience and obviously filled a void...she's still one of my biggest supporters, even ten years after college.

Many examples of such transforming events were evident throughout the e-mail dialogues in this study among these women who have pursued science careers and seem satisfied thus far in their career choices. Another woman scientist stated,

My high school biology teacher was instrumental in sparking my interest in biology. I decided as a junior after taking anatomy that this is what I wanted to study in college. Choosing research as a career came in college because of another great professor who became my advisor and whose lab I did my honors project.

This study's results support the findings of Evetts' (1998) work: the influence of mentors, teachers, and other transforming events during graduate training and even earlier in high school may be gender differentiated. Women tend to report receiving support, encouragement, or special attention or interest that helped them in the pursuit of a scientific career, whereas, as Evetts reports, the men interviewed did not refer to such sources of influence.

Obstacles for Women in Science, Mathematics, and Technology

The researchers' interview results also provide some thought-provoking data concerning the obstacles encountered by women choosing to pursue these nontraditional career paths. Both men and women respondents agreed that there are many obstacles that hinder girls from entering and staying in science careers. The interview data ranged from simple comments saying "science is male dominated" to more reflective responses. Women in science, math, and technology face many of the same hurdles confronted by women in other nontraditional fields, including lack of support from male colleagues, competition and power struggles, and rigid, traditional corporate cultures (Mau, 2003; Evetts, 1998; Norby, 1997). One of the male scientists in our sample explained,

Science is very similar to corporate America in that it's very much a boys' club. For the most part, it seems to be a relatively small group of fat cats helping each other out and taking turns scratching each other's backs. They have their traditions and rules, with the purpose of keeping power exclusively to themselves. As a man, the benefit is that the doors open easier, it's easier to be taken seriously, and you enter with some measure of respect already granted to you. I'm not saying that this is right. There is nothing more unfair than women having to fight for what is normally just given to men....Hard work does not pay off in this world, it's all in who you know and even more importantly, if they like you....I'm sure that as bad as it is for a man, it's a million times harder for a woman.

In addition to the "old boys' network," our study respondents also noted the perception of science as an isolated, demanding, and inflexible career as an impediment to this career choice. A female neuroscientist commented,

I believe that one of the greatest obstacles to girls entering the sciences lies in the presentation of science. If more teachers presented science in a fun way, I think more girls would go into the field. Perhaps more exposure to women scientists would help. Also, I would say that companies need to make it easier for women to be both mothers and scientists by being more flexible and not staying with the 50-plus hour a week mentality.

This respondent is touching on another likely obstacle to girls: careers in science are demanding, and it can be difficult to envision the balancing of multiple roles (*i.e.* mother, spouse) within the context of a science career.

Another academic researcher also touched upon the issue of science's "image":

Girls need to see that science involves a great deal of interaction and is not simply about collecting data. Analyzing that data, discussing it with colleagues, and presenting it is an exciting part of science as well. I think much of the population is under the misunderstanding that science is separate from the rest of the culture, which is, of course, absurd.

The impression that science is devoid of relevance or cooperative interpersonal interaction can be another large obstacle for recruitment of girls into science (Brush, 1991).

Suggesting a Career Choice Model

A model outlining key factors involved in science and technology career choice emerges from this discussion and may be generalizable to other career choices in

nontraditional fields for women. Figure 1 outlines this proposed model. Girls and women pursuing scientific careers (and, perhaps, other nontraditional careers for women) need to include key gender-related variables, at least while women are still a visible minority in the field. Family characteristics include a low degree of gender stereotyping, in addition to parental support and active encouragement for nontraditional careers, while personality variables that are important are high self-esteem and high need for achievement.

The Figure 1 model illustrates that while many factors are important in career choice, the *transforming experience* plays a central role in influencing girls and women to select a career in science, mathematics, and technology. In our model, this transforming experience is defined as important and path-setting interactions with role models and mentors, which include individual interventions, counseling, laboratory projects, and personal relationships. Even when most other factors (such as scientific aptitude and family encouragement) are present, a transforming experience (perhaps at several stages including high school, college, and/or graduate school) may yield the confidence and perseverance necessary for the initial choice towards science to be made and acted upon. A transforming experience also affects the other inputs and the double-headed arrows in the model indicate this. For example, with the encouragement of a mentor, a girl might be able to challenge family or personal gender stereotypes, surmount external obstacles, or confront classroom harassment to reach her goal of a career in science.

Implications and Recommendations

This study investigated some key factors that influence women's initial career choices into scientific fields. In particular, the role of early enriching experiences and/or mentoring relationships emerged as a positive influence on women's selection and success in scientific and technical fields. While our research is limited by its reliance on past experiences and hindsight as well as sample size, some interesting issues emerged, which have some important implications for organizations seeking to encourage the development and retention of women scientists and technologists.

First, girls should be given early opportunities to develop exposure to and confidence in their abilities in science-related activities. Lower confidence in one's ability to understand and partake in science courses is the beginning of girls and women underestimating their abilities and opting out of science as a career. Along with eliminating the well-documented sex biases that exist in classrooms and guidance counselor offices, some girls may benefit from single sex classrooms when studying math and science (American Association of University Women, 1998). Turner and Bowen (1999) found a higher proportion of women in mathematics and physical sciences at women's colleges as compared to coeducational institutions.

Second, there may be a misunderstanding among the general population as to the activities involved in science and science careers. Brush (1991) noted that scientists may be stereotyped as extremely bright but socially awkward ("nerds"); he argued further that when women scientists are featured in the popular press, they are often portrayed as atypical scientists *and* atypical women. A public relations campaign for science and technology may be necessary, both to illustrate the full breadth of possibility, opportunity, and power of a science career, as well as to demonstrate its real-world applications and relevance to human health and life.

Finally, our study results suggest that it is imperative for all students, but particularly girls, to have the opportunity for enriching and transforming experiences related to science. The intervention of key figures appears to be a major influence for girls pursuing nontraditional fields in general, and science fields in particular, at least until equity has been achieved in what are now nontraditional fields for women (see American Association for University Women, 2004). In addition to equity in the classroom and awareness of stereotypes, girls need hands-on experiments, role models and mentors, special

encouragement, and opportunities to meet scientists and to see the interactive process of scientific explorations and discovery. Teachers and professors can help through encouraging girls' participation in clubs, field trips, and science correspondents (i.e., pen pals). Parents can facilitate science-related opportunities by such activities as networking with family and friend scientists, vacation activities, and camp opportunities.

One example of a program that is attempting to correct the deficit of role models in daily life for girls and young women is the *Role Model Project for Girls*, which provides examples of women professionals in a wide range of nontraditional careers and is available on CD-ROM and at their web site (womenswork.org). Many universities participate in the Women in Science and Engineering Research (WISER) program, a research program aimed at women undergraduates. WISER was created in 1993, specifically as a means to stop the "leaking pipeline" and retain women college students in science and engineering. Another example of a business role model group is Women in Apprenticeships and Non-Traditional Occupations (WANTO), which serves as a resource for internships, field trips, and mentors for individual women and as a consultant to businesses interested in recruiting and retaining highly-skilled women in such nontraditional occupations.

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Table 1

Number of Degrees Conferred by U.S. Institutions, 2001-02

Degrees	Bachelors		Masters		Doctoral	
	Total	% to Women	Total	% to Women	Total	% to Women
Total, All Fields	1,291,900	57.4	482,118	58.7	44,160	46.3
Biological/Life Sciences	60,256	60.1	6,205	57.8	4,489	44.3
Computer/ Information Sciences	47,299	27.6	16,113	33.3	750	22.8
Engineering	73,964	18.9	26,920	21.4	5,210	17.2
Mathematics	12,395	46.7	3,487	42.4	958	29.0
Physical Sciences/Science Technologies	17,851	42.2	5,034	37.6	3,803	28.0

Data adapted from U.S. Department of Education, National Center for Education Statistics, 2003

Table 2

Full-Time Workers in U.S. and Weekly Earnings, 2002 Annual Averages

Full-time workers	Number of workers (in 000s)	Percent women	Median weekly earnings	Women's earnings as % of men's
Total, 16 years & older	100,204	43.7	\$609	78.1
Engineers	1,889	10.9	\$1,161	85.6
Math & Computer Scientists	1,808	30.4	\$1,096	81.1
Natural Scientists	475	34.9	\$958	85.7
Technicians & Related Support	3,660	50.1	\$694	70.3

Data adapted from U.S. Department of Labor, Bureau of Labor Statistics, Report 972, September 2004

Table 3

Structured Interview Questions

1. Why did you decide to pursue a career in science?
2. How would you rate the role of your family/parents in your decision?

3. Were there other influences on your choice to pursue a career in science?
4. How early was your first interest in or exposure to science?
5. Do you remember any special experiences that helped to influence your career decision?
6. Do you see any obstacles to recruiting more girls/women entering and staying in science careers?
7. What other careers had you considered other than science?
8. What are the greatest benefits and drawbacks to a career in science for you as a woman/man?

Table 4

Content Analysis Results: Key Factors Influencing Women's Career Choice of Science, Math, Technology

Key Factors	Description
Parental and Family Variables	General support for choices
Personality Variables	Absence of discouragement for nontraditional career Strong math/science aptitude High need for achievement High academic and social self-esteem
Experiential Variables (The transforming experience)	Less sex-typed self-concept Mentors and role models Enriching opportunities: laboratory work, independent studies Exposure to broad range of career choices

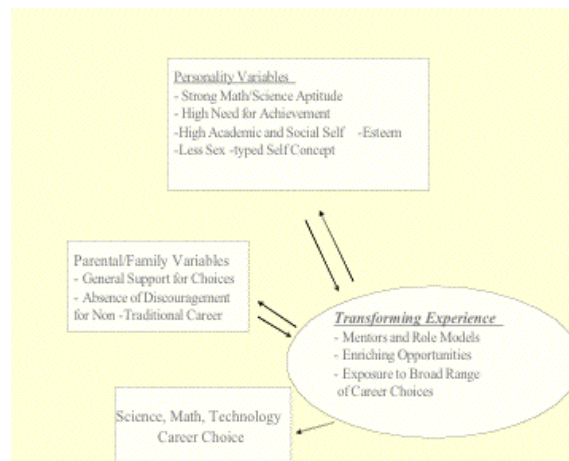


Figure 1. A model of career choice for women in science, mathematics, and technology.

820 N. Michigan Avenue

Chicago, IL 60611

312-915-6537 (office)

312-915-6988 (fax)

areilly@luc.edu

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