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by Karen Young Kreeger

PROFESSION

Turning Points: Scientists Who Leave the Bench Stay Away Forever

Scientists Who Leave the Bench Stay Away Forever

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You can never go home again. Sources for my book on alternate careers told me the switch falls in one direction only.[1] I never dreamed of going back because writing allows me to learn about subjects as different as conservation research and the Y chromosome.

Janet Joy, a senior program officer at the National Research Council (NRC) since 1995, says she has no plans to return to the bench either. Before heading to work at the NRC, she was a neuroscientist at the National Institute of Mental Health. Can you go back? I asked her. "No. I'm seven years out and I still give the same answer."

For Joy and others, the only reentry status they see for themselves would be as postdoctoral trainees, because they would need to refresh their knowledge. After finding a highly satisfying niche for herself at NRC, Joy says, "I have no desire to go back to that status."

Some practical problems also prevent people from returning to research. With each passing year, a former scientist moves further from publishing and funding networks. New discoveries open new technologies. "Science moves very quickly," says Maria Betty, a bioinformatics scientist for Wyeth Laboratories in Princton, New Jersey. Molecular biology, in particular, changes at a rapid pace. "The techniques that I used five years ago have evolved. So it's hard to keep up on the technical side in certain fields."

While studying for her PhD at Oxford University, Betty

realized an academic track would not be right for her. She started out on the bench for Wyeth Research and eventually relocated to the United States. Coworkers often asked her to solve computer problems, and a few years ago she made what she calls a natural progression into bioinformatics.

Betty says that returning to research would mean constant pressure to write grants and papers, low salary, and long hours that sent her from the bench in the first place. Still, some people who switch still fondly recall some re-search experiences. Joy says she misses the camaraderie of a close-knit research group. She'd like to reexperience the satisfaction of mastering a new technical skill. I miss getting outdoors to do field biology.

Though career switchers may sometimes feel nostalgic for their postdoc days, I have never met anyone who returned to bench research. Joy and Betty don't know of anyone either. Career-switching scientists might be able to get back to academia, Joy says, but they cannot return to a lab. Other career alternatives include research administration, technology transfer, or management.

For Betty, Joy, and others I've interviewed, career switching causes little regret. But, if you

want to try a position outside of research science, it's good to remember that you may never be able to return. You may visit home by being an administrator or tech transfer specialist, but you can rarely pick up where you left off.

1. K.Y. Kreeger, *Guide to Nontraditional Careers in Science*, New York: Taylor & Francis, 1999.

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Comment on this article

Searching for the Keys to Unlock the Clubhouse

Unlocking the Clubhouse: Women in Computing, **by Jane Margolis and Allan Fisher. Cambridge, MA: M.I.T. Press, 2002.**

Why are there so few women in computer science and engineering? Is it a problem? If it is, what can be done to ameliorate this problem? Questions such as these took on added importance among proponents of gender equity during the Internet revolution of the 1990s. During much of that decade, the number of jobs in the information technology industry soared, salaries and perks for computer experts also rose precipitously and became much talked about and reported in the popular press. Indeed, the industry claimed a labor shortage great enough to push through the U.S. Congress advantageous legislation to grant H1-B visas to IT professionals from overseas, primarily India and China, while also locating greater numbers of programming jobs outside the U.S. The question of gender in computer science at the turn of the twenty-first century is inextricably bound not only to technological change but also to globalization of the IT industry and the profession. Moreover, gender and other forms of diversity in computing affect the potential for design that better serves a heterogeneous society as computing becomes increasingly pervasive.

Trends in computer science enrollments during the last three decades form an important backdrop to initiatives to remedy inequalities of participation in computing. During the 1970s, undergraduate computer science programs began to proliferate and the number of bachelors degrees awarded reached 8769 by 1979. Women earned 28.1 percent of those degrees. During the first half of the 1980s, the number of bachelor's degrees awarded in computer science increased sharply. By 1987, computer science college program enrollments had reached their peak, as had women's participation at the college level: 39 927 bachelor's degrees were awarded in computer science, of which 34.8 percent were earned by women.

A steep decline occurred in degrees awarded between 1986 and 1991, although not as steep as the preceding growth. The number of computer science degrees awarded dipped to a new low of 25 410 in 1991. The proportion of women earning computer science degrees also declined, to 29.6 percent: only slightly higher than the level reached in 1979. The number of bachelor's degrees awarded remained depressed, but roughly level, from 1991 to 1996. During this latter period, the proportion of women to receive bachelor's degrees in computer science hovered around 28 percent. Recent figures indicate that the number of computer science degrees awarded, and the number of computer science degrees awarded to women, is increasing again, although four years – the period from 1997 to 2001 – is a duration short of a trend.[1]

Is the question of gender diversity in computer science still important now that the Internet bubble has burst? Yes, for several reasons, many of which are covered well in this slim, highly accessible and readable volume by Jane Margolis and Allan Fisher. Their book reports in engaging layman's prose the findings of a four-year study and institutional intervention which took place at the Carnegie Mellon University School of Computer Science between 1995 and 1998. During this period Fisher served as Associate Dean of Undergraduate Education at the School of Computer Science, typically ranked in the top three computer science programs in the United States. Margolis, a social scientist whose specialization is gender, served as a researcher on campus.

The central strengths of the book are twofold. The first lies in the authors' ability to reach a wide audience with an interesting "read" that takes little more than a

[1]Trends in women's participation in computer science education and professions are addressed in detail in [1]. The source for the figures reported here is [2] (Calculations of percentages by author). The National Science Foundation's most recent figures end in 1998. Information on the most recent trends in computer science is based on the Taulbee Survey, administered and analyzed by the Computer Research Association, which surveys Ph.D. granting departments of computer science and computer engineering in the United States and Canada.

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day to complete. The second major contribution is their first-hand account of the strikingly significant institutional changes accomplished at Carnegie Mellon in computing. Throughout the volume, young women and men, most of them students in the Computer Science Program at Carnegie Mellon, are allowed to speak. They do so eloquently and evocatively. It is these extended quotations, drawn from a set of interviews with 97 computer science majors and 30 non-computer science majors that form the heart of the study. Students discuss their parents' comfort level with computing, the use of computing in their home during their childhood, and their perception of the effect of their childhood computing experiences on their budding identity as a computer scientist. As Margolis and Fisher write: "The computer-impaired mother is a stock character in many students' stories" (p. 21).

More poignantly perhaps, these same students describe the sheer delight of finally finding a milieu at Carnegie Mellon where their peers enjoy computing as much as they do. Others, particularly women, express dismay and shock on entering a program in which they mistakenly perceive that "everyone" seems to know much more than they do about computing. Most of the young women don't seem to understand that boys are trained from childhood not to reveal weakness and to hide ignorance. Many of the women quickly and openly reveal their ignorance, thus widening the perceived gap in expertise and comfort in computing as these disparate modes of self-presentation continue and produce the expected results.

As successive chapters trace the development of these students from childhood through their first two years of college, the topic turns to the high attrition rate of women in computer science programs. Here again, the voices of young women are invoked to explain why many of them turn away from a field for which they had marked enthusiasm and obvious ability. A different group of women interviewed by the research team explain how and why they persist in the face of personal and cultural challenges. Through their interviews Margolis and Fisher replicate the findings of Elaine Seymour and Nancy Hewitt, reported in *Talking about Leaving: Why Undergraduates Leave the Sciences* [3]. Surprisingly, the narratives of those who switch out of a major versus those who persist do not differ. It is the decision to exit or persist that differs.

According to the authors, the antecedents of that decision are difficult to capture. Margolis and Fisher report that as a result of a series of programmatic and other institutional reforms, attrition of men and women from the Computer Science Program at Carnegie Mellon became nearly equal by the end of their study. In other words, the interventions produced the intended effects. However, they are careful to point out that attrition levels are likely to differ again by gender if the extraordinary attention to the Computer Science Program and the institutional changes they influenced at Carnegie Mellon wither.

The last chapter recounts the institutional changes at Carnegie Mellon. The transformation of the Computer Science Program there, accomplished in part through Fisher's leadership, has the potential to catalyze and legitimate similar institutional changes throughout computer science education. The significance of these institutional changes is potentially breathtaking, for if Carnegie Mellon sustains its current practices and if other universities follow their example with serious intent, a significant increase in gender equality in computer science is soon to occur – at least at the undergraduate level.

In 1995 the percentage of women who entered Carnegie Mellon's undergraduate computer science program was a mere 7 percent (7 out of 96 students). By 2000, the proportion had shifted to 41.5 percent (54 women out of 130 students) with no weakening of the program's highly competitive admission standards. Reforms included a relaxation of required outside experience in computing. Margolis and Fisher demonstrate that the metric bears no relationship to undergraduate performance in the program. The attraction of greater numbers of women to undergraduate computing is important, but without persistence attraction can lead to greater frustration for institutional leaders as attrition occurs. By 2000, the authors claim that retention rates for women had risen nearly to equal those of young men in the undergraduate program.

The institutional and programmatic interventions recounted by Margolis and Fisher, while singular in their importance, are remarkably simple. Yet as all faculty members know, simple modifications in admissions criteria and curriculum can be devilishly difficult to implement, especially when they relate to efforts to increase diversity with its mistakenly perceived threat to excellence and its correctly perceived threat to the status quo. Success in such institutional reform depends as much on political power and influence as on a solid rationale for change. In this regard, the leadership of Fisher in his role as Associate Dean of Undergraduate Education was key. It has merited wide praise among those who have followed gender and computing for many years. Such praise is well deserved.

In the course of developing and implementing institutional reforms, the authors first documented what they call "the experience gap" between young men and women in computer science. Simply put, on average, young men with an aptitude for computing tend to accrue significantly more practical experience than their female counterparts by the end of high school. The authors demonstrate lack of statistically significant correlation between experience and academic performance. In contrast, they document a significant corre-

lation between previous practical experience and self-perception of competence, particularly for women. As a result of these findings, they broadened the menu of entry-level courses and found that an extra semester that allows students with high aptitude but little experience to "catch up" results in no less opportunity to take upper-level courses given the relatively flexibility in the Carnegie Mellon Computer Science Program after a student has completed first-level, introductory coursework. The criterion of prior experience was dropped from the admissions policy. Moreover, the message "experience is not a prerequisite" was used to recruit women between 1996 and 1998.

In addition to these two modifications to the undergraduate program, several important, yet simple, interventions were implemented in response to the authors' research results. These results, incidentally, simply verify what has been well known in the stream of research on women in science and technology for several years. These interventions include: improved teaching, the addition of greater social context to entry-level computer science courses to render the material less abstract and to draw out its usefulness to society, recruitment of high school students from the advanced placement computer science courses taught by teachers who had attended Carnegie Mellon summer institutes run by the authors and their colleagues. Fisher, Margolis, and their associates improved the level of teaching in the introductory courses, those in which students decide whether to remain in a major or to switch, by strategically using teaching assignments to put better teachers in front of students during their first exposure to computer science at the college level. The authors also worked with teaching assistants – those graduate students who typically perform yeoman's duty providing substantive help, psychological support, and socialization to students in introductory courses – to help them understand the difficulties reported by women, gaps in experience and their meaning, and the variety of motivations (from the pure pleasure of hacking to using computing as an instrument to help society) for entering computer science.

Among the weaknesses in this important book are lapses in method and reporting. Margolis is a former student of Carol Gilligan, the psychologist who developed a path-breaking theory of gender differences in human development reported in the now classic yet still controversial book, *In a Different Voice* [4]. Gilligan stressed the need for psychology, and by extension much of the social sciences, to recognize and theorize differences between men and women in their developmental trajectories and, therefore, in their perceptions of the world and their role in it. For example, psychologists for most of the twentieth century simply excluded women from the research samples upon which the foundations of contemporary psychology have been built. Their inclusion was thought to destroy careful controls that required samples of white men for consistency of subjects. Gilligan dared to develop grand theory using women as her empirical base. Her results suggested a portrait of women as highly relational and forming their worldview through and in relationships rather than through abstract moral reasoning.

Some contend that this view of women, drawn from relatively small samples, is too narrow and simplified. In drawing out distinctions across gender, Gilligan has been accused of essentialism, the demarcation of fundamental gender differences. The danger here is that simplistic distinctions tend to obscure the remarkable variation within each sex and the considerable overlap between the sexes. It may also discount socialization and its role in the social construction of gender. This vastly oversimplified summary of Gilligan's work and the controversy that continues regarding it is mentioned here because of the importance of these ideas for understanding gender and computing.

Gilligan's influence runs through the book, although it is rarely made direct. The most telling moment is a line in which the authors report that the social scientists who interviewed women students in the Computer Science Program were truly astonished to meet women who were deeply excited by and highly proficient in computer science. It was a revelation to them to find, dare I say it, *feminine* women who also were extraordinarily gifted budding mathematicians and scientists. This misperceived divide between the supposed relational, emotional attributes of women and the linear, rationality of science and technology remains a matter of contention among feminist theorists. More to the point, for those who would reform education and industry practices to improve diversity, such underlying assumptions introduce biases into empirical research. Underlying assumptions regarding what women are, what they think, and how they develop are smuggled into hypotheses and interpretations of data influencing research results.

Many of the gender assumptions about the relational propensities of women and their effects may also be American-ocentric. One does not find the same difficulty in many other cultures for women to be viewed as both women and first-rate scientists and engineers. The conflation of American and international students in the book is illuminating in this regard. The two examples of women who persisted in the computer science major, although they found it difficult, are women whose home cultures are Thai and Russian. As these women note, the major is very difficult and they feel isolated, but they have chosen to persist in order to achieve their long-term goals which include economic stability, professional status, and bringing honor to their families.

As the authors note, American women from eco-

nomically advantaged backgrounds often have "the luxury" to choose a field partially according to the degree of personal satisfaction it offers them. The observations of women from outside the U.S. about the need for persistence and hard work are particularly telling in contrast to their American counterparts whose quotations are used in the book. The point here is not to criticize Gilligan's work, which has been of extraordinary importance to science, or the truly important action research reported by Margolis and Fisher. It is simply a call for continued examination of assumptions about gender and clarity regarding the role played by those assumptions in research and in the development of interventions meant to increase diversity.

A second weakness lies more in the reporting of the results than, one suspects, in the results themselves. Computer science majors were interviewed "multiple" times in order to examine their self-reported experiences over the life of their college program. In most longitudinal interview studies, the weakness is attrition in the interviewees. This study is no exception. Only seven women entered the computer science program in 1995. Four of them left the program by the second year. In 1996, 14 women entered the program. Three left in the first year and seven began to question whether they would continue by their second year. Readers are never told how many women entered the program in 1997 or 1998, so it is not possible to get a sense of the number of women at each level in their program who were interviewed. Only two-thirds of the computer science majors were interviewed more than once, meaning that 64 women and men were interviewed for more than one hour. But the exact numbers in each category are not reported.

Readers are told the percentage of Americans and international students as well as the ethnicity of American students, and the authors do well to note cultural differences to the extent possible given the small size of the dataset. In sum, the dataset is too small to make fine-grained comparisons among ethnicities, nationalities, switchers, persisters, and other categories one might like to explore in greater depth. But thematic analysis of interview data with a limited dataset is perfectly appropriate for generating hypotheses. And the hypotheses generated are rich and pave the way for further study.

The authors draw on several related research studies to broaden and lend context to their results. Some studies date from the 1980s. In terms of both gender and technology, research findings become dated quickly, making this subfield of research curiously time sensitive. Women who began a computer science undergraduate program in 1995 were likely to have been exposed to the Internet and World Wide Web only a few years before that. Young men and women whose computing experience has been almost exclusively in a web-based world are likely to be different from the cohort examined by Margolis and Fisher. It is also important to separate research results obtained before the Internet and web became commonplace in most middle-class homes from those studies conducted after. Although it is not by any means the case that the prevalence of the Internet has erased gender inequalities in computing, it has changed the experience of computing in a variety of important ways that remain under-examined.

On balance, the strengths of the book vastly outweigh any weaknesses. Gender and computing remains under-researched at a time when important institutional decisions regarding who does what in an information society are being made. The major contribution made by Margolis and Fisher in this book stems from their linking of an institutional reform of great potential significance as a breakthrough in computer science education with a useful, empirical qualitative data gathering effort. Margolis and Fisher have produced a highly readable account which should find an audience not only among those with a professional interest in computing and society but also among those with little previous exposure to research on gender and computing. This latter audience includes men and women who are high school teachers and guidance counselors, professional computer scientists working in the academy and in industry, other researchers throughout the sciences and engineering, and policymakers with an obligation to ensure equality of access and opportunity.

References

[1] J.E. Fountain, *Women in the Information Age: Technology, Institutions and Gender.* Cambridge, U.K.: Cambridge Univ. Press, forthcoming.

[2] National Science Foundation, *Science and Engineering Indicators,* 2002, Appendix table 2-16, "Earned bachelor's degrees, by field and sex: 1975-98" (selected years).

[3] E. Semour and N.M. Hewitt, *Talking about Leaving: Why Undergraduates Leave the Sciences.* Boulder, CO: Westview, 1997.

[4] C. Gilligan, *In a Different Voice: Psychological Theory and Women's Development,* reissue ed. Cambridge, MA: Harvard Univ. Press, 1993.

Women in Cell Biology

Succeeding in Science at a Liberal Arts College

I'm dragging because I was up until 2:00 am on ebay. It was worth it, though; I won the used Afga X-ray developer for only $1,200. I spent the first part of the morning trying to order lab supplies. I just got off the phone with Fisher, trying to order pipette tips and microcentrifuge tubes. I had to scrounge up a P.O. for them and couldn't find the paper with my account number on it. I struggled to figure out whether I have money in my jumbled grant budget to pay for the supplies. I think I've done some math incorrectly and may have found an extra $200 (or maybe I've done the math correctly and am $200 short, not sure...) I've now got 15 minutes left of the hour before my biochemistry lecture to set up a restriction digest and load a gel. Alas, it's not to be, for as soon as I step outside my office I spot two students from my immunology class approaching me. Those precious 15 minutes are disappearing...

If you can imagine funding your entire laboratory on a $2,000 research grant, you will begin to comprehend my joy at finding used lab equipment for sale on ebay.

Dictionaries define fragmented as broken into pieces. There is no better adjective to describe what it is like to be a scientist at an undergraduate liberal arts college, in my case at Simmons College where the undergraduates are women. On any given day, I am called upon to be a PI, a lab manager, a lab technician, a grants administrator, a teacher, a career advisor, and sometimes a soft place to land for an unhappy 18-year-old. Imagine for a moment, your lab with no technician, no postdocs, and no grad students. Who's available to do the experiments? YOU. You would be making the plates, purifying the plasmids, lysing the cells, running the gels, washing the blots, and so on. Calculate the number of productive hours your postdocs, techs, and graduate students spend at the bench performing experiments. Now imagine that it is only you and maybe a few junior undergraduates. It's a frightening thought.

Collaboration and Fragmentation

At the moment, my lab is working on three very different projects. I'm collaborating with one colleague who is characterizing an *E. coli* protein possibly involved in transcriptional silencing. I'm collaborating with another colleague who is exploring the evolution of a murine mutation involved in patterning in the mouse. And finally, my lab's own project is characterizing the functional relevance of a mammalian B cell receptor protein and its downstream protein partner. This means that I'm a molecular, developmental, and cellular biologist, with a dash of biochemistry and immunology thrown in. Talk about "fragmented!" I am truly never bored, but I face a Sisyphean task trying to keep up with all the literature.

By definition, liberal arts colleges, and hence their departments, are small. Consequently, I am the sole representative of several fields in my department. I am the only biochemist in the chemistry department and the only immunologist in the biology department. My office sits between those of an inorganic chemist and a physical chemist. They have become versed at determining if there really is a band on the Western blot I just ran, and I have become an expert at analyzing their MALDI-TOF mass spectra. Hence, collaboration is essential; it is impossible to do research in a vacuum.

Where else could I collaborate with some great researchers in my field, without the fear of losing my funding and the pressure to churn out publication after publication?

Teacher-Scientist or Scientist-Teacher

I teach three courses in an average semester. I have about 30 advisees each semester, and there are usually two to three students doing independent research in my laboratory each year.

This translates into about 15-20 student contact hours per week. My students have constant access to me, and my door is always open for conversation and a cup of tea. I mentor these students, and counsel them, and, hopefully, serve as a role model so that they will go on to become scientists themselves. But first I have to teach them biochemistry and immunology—without a TA to run the labs, go

over homework problems, or grade the 10-page take-home exams I'm fond of giving.

So, am I a teacher-scientist or scientist-teacher? Does it matter? Does the fact I'm a teacher-scholar make me less of a "real scientist" in the perception of the larger research community? Will researchers at major research institutions take me seriously?

Will major grant programs consider me "worthy" of receiving funding? If you can imagine funding your entire laboratory on a $2,000 research grant, you will begin to comprehend my joy at finding used lab equipment for sale on ebay.

Why would I choose this path? I get to dabble in many scientific disciplines daily.

Where else could I apply my training in molecular biology to learning how to run a MALDI-TOF mass spec? Where else could I watch the epiphany of understanding dawn on the face of a junior when she finally appreciates that cell biology and biochemistry are actually related? Where else could I write, be awarded, and control my own grants, and still manage to wield a pipette? Where else could I collaborate with some great researchers in my field, without the fear of losing my funding and the pressure to churn out publication after publication?

Am I exhausted at the end of the day? Without question, but so is anyone who is passionate about his or her work. I am excited when a manuscript is accepted for publication, but I am equally excited when my students are accepted into graduate school.

My very first student will shortly defend her Ph.D. thesis at MIT. So the next time you have particularly skilled graduate students join your lab, think about where they came from. Think about the scientists who trained them at the undergraduate level and inspired them to continue. I am a scientist and I am a teacher.

It doesn't matter in which order you write the words, because on any given day I am equally both. And I would not have it any other way. ■

—Jennifer Roecklein-Canfield
for the Women in Cell Biology Committee

Dinner Meet-Up

At the ASCB Annual Meeting by yourself? Tired of eating alone or grabbing a sandwich at Starbucks? Drop by the Meet-Up poster in the Grand Foyer (lobby) of the Washington, DC, Convention Center at 6:00 pm each evening to find potential dining companions. A list of interesting restaurants will be posted; you figure out with whom and where to go. *(Sponsored by the Women in Cell Biology Committee)* ■

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