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TALES OF WOMEN IN SCIENCE AND TECHNOLOGY:

HOW WOMEN COMPUTER SCIENTISTS IN ENGINEERING

ENVIRONMENTS EXPERIENCE THEIR PROFESSIONS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the

Graduate School of the Ohio State University

By

Linda S. Condron, B.S., M.A., M.S.

* * * * *

The Ohio State University
1997

Dissertation Committee:

Suzanne K. Damarin, Adviser

William D. Taylor

Jane M. Fraser

Approved by

_____
Adviser
College of Education

UMI Number: 9813243

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Ann Arbor, MI 48103

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1997

ABSTRACT

The organizing element in this dissertation is the "story." The unifying theme is that many stories can be told about women in relation to science, mathematics, engineering, and technology--"the technical realm," as I call it. This dissertation examines stories of women in the technical realm. Indeed, it contributes to this literature stories about women computer scientists working in engineering environments.

My research methodology is qualitative and post-positivist. I assume a feminist standpoint (Hartsock, 1983; Harding, 1991, 1993) in asking the question, "How do women experience their professions as computer scientists working in engineering environments?" I report on women's experience with/in the technical realm with a postmodern awareness of conflict, contradiction, paradox, and the situatedness of all knowledge and understanding (Haraway, 1991; Richardson, 1994).

In the literature review, I consider some of the common stories about women and science and technology. There are stories throughout history that demonstrate women have always been active with/in science and technology. Archeological study contributes such stories as well. There are also stories of the consistent absence of women from the technical realm. There are stories that women are, by nature, disinclined toward mathematical skills, for instance. Yet there are stories that women are just as competent as

men in every mathematical skill that has been defined, operationalized, and measured. Evelyn Fox Keller (1985), tells a powerful story of science and technology being defined as male, leaving women no place from which to engage with/in science and technology without calling into question their very identities as women.

In my study, I interviewed twenty women computer scientists who do research and development work in engineering environments. In this dissertation I present the "stories" of five of these women in some detail. I proceed to examine contradictions in the data in discussions of (1) the insider-outsider status of the women, (2) their non-technical extra-professional interests and activities, and (3) their simultaneous lack of and valuing of diversity in their workplaces. This dissertation ellucidates contradictions and consistencies between stories in the scholarly literature and how women experience their technical professions.

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Dedicated

to the Memory of my Parents:

Claire Mary Hoeper Condron
and
Robert J. Condron

and to the
Inspiration and Empowerment
of those who follow in
the next generation:

Ben Condron
Loren Condron
Kaitlyn Harfmann
Alene Harfmann

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VITA

April 5, 1950.....................................Born - Cincinnati, Ohio

1972...B.S., Early and Middle Childhood Education
                                                   The Ohio State University

1973...Substitute Teacher, Columbus Public Schools

1973-1978 ....Teacher, St. Matthias School, Columbus

1978-1980 ....Substitute Teacher, Columbus Public Schools

1979-1980 ....Graduate Teaching Associate, Mathematics
                                                   Department, The Ohio State University

1980...M.A., Mathematics Education
                                                   The Ohio State University

1980...Substitute Teacher, Hayward Public Schools,
                                                   Hayward, California

1981...Lecturer, Mathematics Department
                                                   California State University, Hayward

1981-1987 ....Systems Analyst, Department of Engineering
                                                   Research, Pacific Gas and Electric Company,
                                                   San Ramon, California

1987-Present.....................................Graduate Research Associate, University
                                                   Technology Services, The Ohio State
                                                   University

1990...M.S., Computer and Information Science
                                                   The Ohio State University

PUBLICATIONS

Fiamingo, Frank, Debula, Linda, & Condron, Linda. (1996). *Introduction to Unix*. Columbus, OH: The Ohio State University. Available http://www-wks.uts.ohio-state.edu/unix_course/unix.html.

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FIELDS OF STUDY

Major Field: Education

Areas: Instructional Design and Technology
Cultural Studies in Education
Computers in Education
Feminist Studies

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CHAPTER 1

INTRODUCTION

The organizing element in this dissertation is the "story" (Lather, 1991; Van Maanen, 1988; Wolf, 1992). The unifying theme is that many stories can be told about women in relation to science, mathematics, engineering, and technology--"the technical realm," as I call it. There are stories throughout history that demonstrate women have always been active with/in science and technology. Archeological study contributes such stories as well. There are also stories of the consistent absence of women from the technical realm. There are stories that women are, by nature, disinclined toward mathematical skills, for instance. Yet there are stories that women are just as competent as men in every mathematical skill that has been defined, operationalized, and measured. This dissertation examines stories of women in the technical realm. Indeed, it contributes to the literature of women in the technical realm stories about women computer scientists working in engineering environments. In particular, I have interviewed twenty women computer scientists who work in science and engineering environments (as distinct from business and administrative environments), doing research and development.

In my research, I am interested to know more about the (post?)modern technical world inhabited by women computer scientists working in engineering environments. What do they do at work? Why is this work important to them? How interesting/exciting do they find their work? How do they fit (or not fit) into their respective work groups? How much say do they have/take in deciding what to work on and how to approach that work? To what extent do they collaborate on the job with other engineers/technical experts? How relevant are their histories of formal studies, particularly mathematics? In what ways, if any, do their technical careers affect their relationships outside their workplace? How does their sex/gender interact with their technical endeavors? In what specific ways is their being female the cause and/or the effect of their experience of their technical professions?

I am also interested to know more about how women who are engineers negotiate, ignore, accept, resist, subvert, and/or exploit the conflicting and contradictory stories about women in the technical realm. How do they perceive the conflict between their own mastery of mathematics and science, and the social stereotype of mathematics and science as a masculine realm? How do they interpret the conflict between their own technical expertise and the social stereotype of women as befuddled by technology? Is their triumph over the barriers to their technical professions a struggle of the past or an ongoing struggle? In a nutshell, the overriding question that guides my research is, *"How do women experience their professions as computer scientists working in engineering environments?"* On the other hand, the underlying organization of this dissertation is revealed by the question, *"What are some of the stories that can be told about women with/in science and technology?"*

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In Chapter 2, I pursue five different story lines in the literature about women and technology. In the literature, these stories are most often told separately and without reference to each other. In this dissertation I explore how they come together in the lives of some women. These stories are:

Women in Science and Technology. From what is known of the earliest times in human prehistory, both women and men made substantial technical contributions to the survival of their societies. The earliest written history, coming from Egypt and Mesopotamia, gives clear indication that women were involved in the technologies of the times. Since the 1970s and early 1980s in this country, much research has been devoted to rediscovering and telling the stories of women who have made contributions throughout history to science and technology.

Women Excluded From Scientific and Technological Work. Despite the evidence of women's involvement with science and technology since the earliest records of humanity, it cannot be overlooked that women are proportionately under-represented in the realm of science and technology in these present times. The absence, indeed, the exclusion, of women from public involvement in the development of technology has a long history. Certainly one of the most fundamental of the forces against which women have struggled in order to be able to do science has been the exclusion of women from educational opportunity. Women have also been excluded from public meetings of men, meetings in which knowledge, theory, discovery, invention, and speculation have been shared. The institutionalization of professions has played a large role in the exclusion of women as well.

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The Marginalization of Women in Science and Technology. While there is a public perception that more and more women are studying for and entering careers in engineering, this perception is not well-supported by statistics (Spertus, 1991). Many women become discouraged and leave college science, engineering, and mathematics programs before completion; many women who do finish engineering degrees do not pursue or stay in engineering careers (Ng & Rexford, 1993; Seymour & Hewitt, 1994). Only eight percent of engineers are women, according to NSF reports. Furthermore, of the women who do become engineers, a lower percent are in management than male engineers who are in management. Women engineers have a lower average annual salary and higher unemployment and underemployment rates than men engineers (NSF, 1996). The technical realm is not very welcoming, supportive, and encouraging toward women.

Science Defined as Male. The term "science," coming from the Latin verb "to know" once referred to any system of knowledge. Since the time of Bacon's specification of the scientific method, however, science has come to have a very narrow definition, emphasizing power and control. As Keller (1985) has shown, this narrow definition of science places white men in the subject or power position, and places women and nature in the position of controlled object.

Mathematics, Education, and Gatekeeping. Mathematics was not taught at all in colonial times in the United States. As a subject of study, it was gradually introduced to boys, but generally not girls, in support of commercial efforts. Later, the study of mathematics came to be valued for the mental discipline that was associated it. As college engineering programs were instituted in the late 1800s and early 1900s, mathematics test scores

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assumed a gatekeeping function. Traditionally girls have not been as rigorously schooled in mathematics; they came to be thought of as less able to think mathematically than boys. It is an all too common misconception that women and girls cannot do mathematics as well as men and boys. Though boys elect to study mathematics more than girls, and thus score higher on measures of mathematics achievement, research repeatedly fails to find significant differences in the mathematical abilities of girls and boys.

Following the explication of stories in the literature, Chapter 3 describes how I go about the gathering of the stories of twenty late-twentieth century women employed as computer scientists doing research and development in engineering environments.

In Chapter 4, I present five of these women's stories, which seem to be representative of the study in a number of ways, including age of the women, company of employment, and educational background. These women were interestingly articulate and reflective in talking about their experience.

In Chapter 5, I pursue three story lines of conflict and contradiction that emerge across the data I collected talking to women in computer science in engineering environments. The first is the story of the women as both insiders and outsiders with respect to their professions. The second is concerned with the extent to which the women choose to leave the technical behind when they leave work, a different choice than they see in the behavior of many of their male peers. The third is about the conflict between their appreciation of the diversity of people in their workplaces and their lack of appreciation of the lack of diversity of educational opportunity and socio-economic background among the people in their workplaces.

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I close, in Chapter 6, with a reflexive tale. Here, I discuss my process of negotiating meaning in the midst of the contradictions inherent in the study. Here, I also address the issue of the validity of the study. I end with discussions of implications and consistencies across the literature and the study.

CHAPTER 2

STORIES FROM THE LITERATURE

The literature about women and science, technology, engineering, and mathematics is vast. It does not tell a single coherent story about women's relationships to the technical. In fact, it tells many different stories. These stories both contradict and complement each other. The intersections, disjunctions, complementarities and contradictions among these stories seem to defy enumeration and systematizing. In this chapter, rather than attempt to make a single coherent story, I tell five stories about women in science and technology. I make no claim that these stories constitute a comprehensive report of the relations of women with science and technology. Rather, I intend to demonstrate by the range of these stories how women's involvement with/in science and technology, and the literature about that involvement, is vast and complex.

Women in Science and Technology

From what is known of the earliest times in human prehistory, both women and men made substantial technical contributions to the survival of their societies. The gathering of plants for purposes of nourishment and healing, the design of tools and shelters, the processes of cooking and pottery

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making are all examples of early technological endeavor in which women were no doubt involved. "Mythological evidence connects women strongly with the taming of fire" (Stanley, 1983, p.7). The earliest written history, coming from Egypt and Mesopotamia, gives clear indication that women were involved in the technologies of the times, owning property, directing workers, keeping records of production, health, and celestial observation. Especially in the 1970s and early 1980s in this country, much research went into rediscovering and telling the stories of women who have made contributions to science and technology throughout history.

Botany, medicine, and agriculture may be thought of as the earliest sciences; mathematics and astronomy developed in support of these endeavors. Women were included on equal terms among the Pythagoreans (c. 500 BC), though this fact is obscured by the use of the term "Brotherhood" to refer to them. Hypatia of Alexandria (370-415 AD) is perhaps the most famous woman scientist of ancient times. Her best known work is in algebra. "The last pagan scientist in the western world, her violent death coincided with the last years of the Roman Empire" (Alic, 1986, p. 41). To a great extent, science was dormant in the western world for 1000 years after that, though in the East, it steadily advanced, pursued by women as well as men.

The practice of medicine and surgery by women in Europe continued through to the Renaissance in informal ways and later in small intellectual and monastic communities (Noble, 1992). One woman, Trotula, of the eleventh century southern Italy school at Salerno, was particularly famous and well-respected for her knowledge, her advanced techniques, her teachings and her writings about health, child bearing, and other medical and surgical issues. Alic (1986) tells story after story of women throughout Europe who

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were deeply involved in scientific endeavors of every sort up to this century. In Kistiakowsky's (1979) brief summary of famous American women in science through the early part of the twentieth century, the ancient trend of women in botany and astronomy is once again visited. The first of these famous American women scientists is Jane Colden (1724-66), a botanist; and the second, Maria Mitchell (1818-89), is an astronomer.

Other authors tell stories of more recent women scientists. Rosalind Franklin's outstanding work on DNA, which paralleled the work of Watson and Crick, is recognized in the writings of Richter (1982), Gornick (1983), Behringer (1985), and many others. Keller (1983, 1985) writes extensively of the accomplishments and scientific methods of Barbara McClintock (1902-1992), "one of America's most eminent cytogeneticists" (1983, p. 139), and recipient of the 1982 Nobel Prize.

In computer science, groundbreaking contributions include work by Ada Lovelace (1815-52), who wrote the first computer programs, nearly a century before technological advances made it possible to build an actual computer (Alic, 1986); Grace Hopper (1906-1992), among whose many accomplishments was her instrumental involvement and leadership in the design of the computer language, COBOL (COmmon Business Oriented Language); and Adele Goldstine, who provided leadership and expertise in the design of software for the computation of ballistics tables on the ENIAC (Electronic Numerical Integrator and Computer), the first American computer (Gurer, 1995; Perry & Greber, 1990). Another expert in computer science and electrical engineering, Ruth Davis, was appointed by the Carter administration to manage nearly 100 United States government centers for research and development (Abelson, 1979).

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Of course, what I have enumerated here barely skims the surface of the "women have always been in science and technology" story. Besides the fact that many, many more women have used and made contributions to science and technology than I could mention here, there are other facts, other stories, beneath the surface of this story of involvement, interest, and achievement.

The next two stories are entangled with each other and difficult to sort out. Whereas it can be said that women have *always* been involved with/in science and technology, it can also bereview, the fourth "story," n *excluded* from involvement with/in science and technology. These two statements directly contradict each other, of course, and perhaps that makes them even more interesting. In any case, an investigation into either of these stories leads inevitably to another story: women who do find themselves interested and engaged with/in science and technology are marginalized.

Women Excluded from Science and Technology

> At the core of modern science lies a self-reinforcing system whereby the findings of science (crafted in institutions from which women were excluded) have been used to justify their continued absence.
>
> --Londa Schiebinger (1993, p. 3)

Despite the evidence of women's involvement with science and technology since the beginning of humanity, it cannot be overlooked that women are proportionately under-represented in the realm of science and technology in these present times. The absence--exclusion, in fact--of women from public involvement in the development of technology has a long history. Many of the authors who write about the contributions of women to

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science write also of the forces against which they have struggled to be able to even do science, recognition aside. These forces are complex. Certainly one of the most fundamental of the forces against which women have struggled in order to be able to do science has been the exclusion of women from *educational opportunity*. Women have also been excluded from *public meetings* of men, meetings in which knowledge, theory, discovery, invention, and speculation have been shared. The *institutionalization of professions* has played a role in the exclusion of women as well.

In the early days of the United States, education for girls was encouraged on the basis that it would improve their ability to run a household and rear children. But it was not as available or extensive as the education boys were offered. Harvard College, the first college in the New World, was established for men in 1636. Oberlin College was the first, in 1837, to allow women to enroll for formal higher education.

Lerner (1969) writes that American colonial women were employed in many kinds of productive activities. This was partly due to the immediacy of the colonists' struggle for survival; partly to the Puritan view that idleness is sinful; and partly to the fact that, since there was a shortage of women, colonial women enjoyed an enhanced status and freedom of activity. Women learned their skills, as did men, by apprenticeship. They were engaged in teaching as well as such technological and scientific endeavors as smithing, milling, tanning, agriculture, medicine, and midwifery. As the hierarchical structure of the colonial society stabilized, women were not incorporated into the ranks, but rather were associated with their fathers or husbands in the hierarchy. With the growing maturity and later, independence, of the nation came a push to establish the institutions which

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would provide the foundations of society. The standardization of medical training and licensing in the late 1700's and early 1800's excluded women, as if they had never been involved to begin with. "This process of pre-emption of knowledge, institutionalization of the profession, and legitimation of its claims by law and public acceptance is standard for the professionalization of the sciences" (Lerner, 1969, p.7). Thus, even as educational opportunities for women were improving, institutionalization of the medical profession was one step ahead and, along with patriarchal assumptions about the organization of society, resulted in the exclusion of women from a field of endeavor they had pursued throughout history.

The industrial revolution introduced additional opportunities and conflicts for women interested in technology. Engineering became institutionalized as a profession, with a standardized course of education, involving physics, chemistry, and mathematics, and a hierarchy of support jobs such as draftsperson and technician (Hacker, 1983). The support jobs, having lower status, requiring less formal education, and paying lower wages have become more readily available to women and other marginalized groups. They are also the first jobs to be eliminated when times are hard economically or due to automation. The phenomenon of "deskilling" whereby these support jobs are de-personalized and automated is powerfully described by Garson (1988) with examples from McDonald's, airline reservation systems, and social work, among others.

In the political climate of the 1960's and 1970's women as well as minority groups began to gain access to educational and employment opportunities which had previously been reserved almost exclusively for white men. The Science and Technology Equal Opportunities Act of 1980

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mandated that a biennial report, Women and minorities in Science and Engineering, be published by the National Science Foundation (NSF). It is reported in the 1990 volume that as of 1988, women constituted 45 percent of the total U.S. workforce, but only 16 percent of the total science and engineering workforce. Among engineers, only one in 25 was a woman. In 1986, women scientists and engineers earned an average of 75 percent of the average annual salary of men in science and engineering. Also, underemployment and unemployment rates are higher for women scientists and engineers than for men scientists and engineers (NSF, 1990).

The Marginalization of Women in Science and Technology

By mandate of the Science and Technology Equal Opportunities Act of 1980, biennial reports are published on the status of women in science and engineerng. These reports examine women's participation in science and engineering education and employment. The eighth in this series (NSF, 1996) reports that women constitute 46 percent of the total U.S. workforce, but only 22 percent of the total science and engineering workforce. And only 8 percent of engineers are women. Statistics demonstrate that women scientists and engineers are more likely than men to be employed outside their field, employed part time, or unemployed (NSF, 1996, p. xiv). Among masters level scientists and engineers, 9 percent of women are managers, while 13 percent of men are managers. A similar gap holds for doctoral level scientists and engineers, with 21 percent of women being managers and 25 percent of men being managers (NSF, 1996, p. 71). Among doctoral level scientists and engineers, women are more likely to be employed in academia than are men (NSF, 1996, p. xiv). Yet the women are less likely to hold tenure track

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positions, less likely to be tenured, and less likely to hold full professorships than doctoral level men (NSF, 1996, p. xv).

In January, 1995, "Women in Computing" was the theme of the *Communications of the ACM*, the monthly publication of the Association for Computing Machinery. An article by Ellen Isaacs surveyed the hiring, promotion, and salary discrimination women in computing professions face. They tend to be hired into lower status, lower paying jobs than men, and "the gap between men's and women's salaries and promotion rates grows at an increasing rate" (Isaacs, 1995, p. 58) over time. The women earn 86 percent of men's salaries, and this gap widens to 82 percent among managers. Even after factoring out the common explanations for these salary differences— namely that "women choose professions that pay less, and they have less experience than men of the same age because they take time off to raise children" (p. 59)—women only earn 91 percent of what men earn.

In another article, entitled "Human nature and the Glass Ceiling in Industry," in the same January, 1995 issue of *Communications of the ACM*, Kathleen Hemenway describes a set of four forces that contribute to the marginalization of women working in the technical realm, and suggests six counterforces that could be applied to the task of "turning around the situation" (Hemenway, 1995, p. 59). She suggests that the success of many companies may depend upon adopting more equitable and "proactive measures to counteract . . . the barriers that block the advancement of women" (p. 60). But it has yet to be seen if this will be done.

Women are marginalized educationally as well as occupationally. Women aften tell stories of having been discouraged from studying mathematics or science by their teachers, counselors, or parents. In classes,

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girls are called upon less often than boys, asked less substantive questions than boys, and given less task-specific attention and encouragement than boys, Klawe and Leveson (1995) remind us. While their science, mathematics, and engineering grades are just as good as or better than those of their male college classmates, women's self-esteem and confidence in their mastery of these subjects decreases over the course of their college experience; in contrast, men's confidence increases (Klawe & Leveson, 1995; Seymour & Hewitt, 1994; NSF, 1996). Large percentages of women change undergraduate majors from science, mathematics, statistics, engineering, and computer science to other majors. In their study, Seymour & Hewitt (1994) found particularly high percentages of women switching from mathematics and computer science majors to other majors (p. 43). "Graduate school is, perhaps, an even chillier place for women than undergraduate study," report Klawe and Leveson (1995). "There is evidence the dropout rate for women in [computer science] Ph.D. programs is double that for men" (p. 32). The result of this situation is that some college computer science programs have no women faculty at all. Women studying computer science have very few role models in the classroom.

The stories I have touched upon up to now in this literature review form a sort of unit. They tell of women having always been involved in the technical realm, having always been excluded from the technical realm, and having always been kept in the margins of involvement with/in the technical realm. In the next section, I examine the fundamental maleness of science, mathematics, and the technical; I review Evelyn Fox Keller's *Reflections on Gender and Science.*

Science Defined as Male

The term "science," coming from the Latin verb "to know" once referred to any system of knowledge. Since the time of Bacon's specification of the scientific method, however, science has come to have a very narrow definition, emphasizing power and control. As Keller has shown, this narrow definition of science places white men in the subject or power position, and places women and nature in the position of controlled object. Furthermore, it leaves women no place from which to engage with/in science and technology without calling into question their very identities as women. Evelyn Fox Keller, a mathematical biophysicist and historian of science, tells this story in her book, *Reflections on Gender and Science* (1985). There she asks the question, "How much of the nature of science is bound up with the idea of masculinity, and what would it mean for science if it were otherwise?" (p. 3).

She begins by tracing how mind and nature were coupled and de-coupled in Western history. The political, economic, social, and intellectual circumstances of the seventeenth century provide much to examine. Keller finds it "possible to describe the intellectual history of that period schematically, in terms of two competing philosophies, hermetic and mechanical: two visions of a 'new science' that often competed even within the minds of individual thinkers. In the hermetic tradition, material nature was suffused with spirit. . . . By contrast, the mechanical philosophers sought to divorce matter from spirit" (p. 44). The main adherents to what Keller refers to as the hermetic tradition, and Alic (1986, p. 5) refers to as the "vitalistic philosophy," so brilliantly expounded by Anne Conway (1692), were the Renaissance alchemists, who found inspiration in the sixteenth

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century works of Paracelsus. The "seventeenth century alchemists were principally concerned with the transformative, especially curative, powers of chemically prepared medicines; their pursuit of the transmutation of base metal into gold was largely emblematic" (p. 45). The main representatives of the mechanical philosophy were proponents of the work of English philosopher Francis Bacon (1561-1626).

Keller examines Bacon's vision, in which "the principal metaphor is sexual," and the accompanying "marital imagery" is aggressive (p. 19). It was Bacon "who first and most vividly articulated the equation between scientific knowledge and power, who identified the aims of science as the control and domination of nature. . . . In viewing science as power, he thought he saw salvation" (p. 33). Keller points out that to today's "defenders of science," Bacon's model "speaks more for the technologist than for the scientist, whose search it is said is as much for transcendence as it is for power" (p. 34). Keller, however, finds Bacon's model complex and rich, and true "to the spirit of the scientific impulse" (p. 34). Bacon, furthermore, "provided the language from which subsequent generations of scientists extracted a more consistent metaphor of lawful sexual domination" (p. 34). Bacon's vision was "of a science leading to the sovereignty, dominion, and mastery of man over nature" (p. 34). "Bacon's use of gender is implicated in his conception of mastery and domination. The fact that mastery and domination are, invariably, exercised over nature as 'she' can hardly escape our attention" (p. 35). In the following passage from page 36 of her book, Keller pulls from the works of Leiss, Farrington, Anderson, and Spedding et al, as well as from Bacon's writings, to demonstrate metaphorical application of sexual imagery:

> "Let us establish" [Bacon] wrote, "a chaste and lawful marriage between
> Mind and Nature" (quoted in Leiss 1972, p. 25). . . . It is Nature herself

who is to be the bride, who requires taming, shaping, and subduing by the scientific mind. "I am come in very truth leading to you Nature with all her children to bind her to your service and make her your slave" (Farrington 1951, p. 197). Elsewhere, more gently, [Bacon] writes: "I invite all such to join themselves, as true sons of knowledge, with me, that passing by the outer courts of nature, which numbers have trodden, we may find a way at length into her inner chambers" (Anderson 1960, p. 36). Nature may be coy, but she can be conquered, "For you have but to follow and as it were hound nature in her wanderings, and you will be able, when you like, to lead and drive her afterwards to the same place again" (Spedding et al. 1869, 4: p. 296). The discipline of scientific knowledge, and the mechanical inventions it leads to, do not "merely exert a gentle guidance over nature's course; they have the power to conquer and subdue her, to shake her to her foundations" (Spedding et al 1869, 5: p. 506). All of this, however, in the service of truth. In conquering and subduing, in shaking her to her foundations, we do not so much transform Nature as reveal her, for "the nature of things betrays itself more readily under the vexations of art" (meaning practical, or mechanical, art) "than in its natural freedom" (Anderson 1960, p. 25) (p. 36).

Power was a central focus in the vision of a new science for both the alchemists and the Baconians, but they had differing notions of power, and Keller finds that these "can readily be seen in the opposing sexual metaphors underlying their visions" (p. 48):

> If the root image for Bacon was a "chaste and lawful marriage between Mind and Nature" that will "bind [Nature] to [man's] service and make her [his] slave" (Farrington 1951, p. 97), the emphasis was on constraint, on the disjunction between mind and nature, and ultimately on domination. By contrast, the root image of the alchemists was coition, the conjunction of mind and matter, the merging of male and female. As Bacon's metaphoric ideal was the virile superman, the alchemist's ideal was the hermaphrodite. Whereas Bacon sought domination, the alchemists asserted the necessity of allegorical, if not actual, cooperation between male and female. Power for them was to be achieved through "cohabit[ing] with the elements" (Agrippa, from Yates, 1969, p. 136) (p. 48).

At the same time the philosophy of modern science was developing, a mania about witchcraft, and an associated fear of female sexuality, was also

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developing. Controversy raged over whether to attribute abstruse natural phenomena, experienced through encounters with witches, to God or to the Devil. "To the alchemists, God was immanent in the material world, in woman, and in sexuality" (p. 59). To proponents of the mechanical, experimental science, "much of what the alchemists took to be the sign of God was in truth the mark of the Devil" (p. 59). Kinship between spirit and matter, "between knowledge and erotic sexuality, and between experimental and spiritual knowledge" (p. 58) was a notion that failed to "demarcate Nature adequately: it failed to demarcate the 'Bounds of sober Enquiry'--the domain of proper knowledge. Its understandings remained subverted by the 'Woman in us,' seducing us into the 'recondite knowledge,' which is, by its nature, ungodly, even Satanic" (p. 58-59). Ultimately, "the founding fathers of modern science . . . embraced the patriarchal imagery of Baconian science and rejected the more participatory and erotic language of the alchemists" (p. 54).

Keller comments that "if modern science evolved in, and helped to shape, a particular social and political context, by the same token it evolved in conjunction with, and helped to shape, a particular ideology of gender" (p. 43). She takes a long hard look at how gender identity develops, under what circumstances, and with what consequences for science and technology. She turns to psychoanalytic theory for a discussion of the bond between mother and child, the separation of the child from the mother, the development of self and gender identities that accompanies the separation, the role of the father in representing autonomy and authority in separation, and the differential effects of the separation process for girls and for boys. She finds the following. Because children are mostly dealt with--especially given

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emotional support--by their mothers, their sense of personal autonomy and self (their subjectivity) develops in opposition to the object mother. Furthermore, for boys, gender identity develops in opposition to everything that is associated with the (female) object mother. The separation process is supported by the presence of and by the example of the father, who represents--and demonstrates the effectiveness of--authority, autonomy, not-mother, and, in the final analysis, not-female. Thus, boys' self-identity and gender identity rest on a developmental process that accentuates separation. This exaggerated notion of separation is then carried into a notion of autonomy that objectifies the other, particularly the female other. Keller writes:

> What I am suggesting, and indeed trying to describe, is a network of interactions between gender development, a belief system that equates objectivity with masculinity, and a set of cultural values that simultaneously (and conjointly) elevates what is defined as scientific and what is defined as masculine. The structure of this network is such as to perpetuate and exacerbate distortions in any of its parts--including the acquisition of gender identity (p. 89).

So, emerging from a child's developing sense of self, gender, reality, and agency are four critical elements of Western scientific ideology as we know it. These are autonomy, masculinity, objectivity, and power. Keller advocates shifting the meanings of these terms conceptually through "a shift of developmental norms" (p. 97). Again, from Keller:

> *Autonomy*, at one end of its range, connotes a radical independence from others, mapping closely onto an interpretation of *objectivity* that implies a reductive disjunction of subject from object--an interpretation I have labeled 'objectivism.' It is this end of the spectrum of objectivity that . . . correlates with a conception of masculinity denying all traces of femininity. . . . [T]he same interpretation of autonomy also correlates with a conception of power as power over others, that is, with power defined as domination. Thus

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the linkage between objectivity and domination that feminists have discerned is not intrinsic to the aims of science, or even to the equation between knowledge and power, but rather to the particular meanings assigned to both power and objectivity. In short, . . . this linkage is a derivative of the particular biases that are cast by modern Western culture on all aspects of psychological (cognitive as well as emotional) development (p. 97).

Bacon's vision of a transformation of "man's" relation to nature by means of a powerful and controlling science and technology was not immediately universally embraced. In fact, "the history of science [shows] that science, in practice, is not and has never been a monolithic enterprise" (p. 65). But Bacon's "central metaphor--science as power, a force virile enough to penetrate and subdue nature--has provided an image that permeates the rhetoric of modern science" (p. 48). Having considered Bacon's vision of a modern science and technology, and the times within which it evolves into a prevailing ideology; and having considered the relationship of a particular kind of autonomy and objectivity to masculinity and modern science and technology, Keller turns to look at how science is "made." She considers examples of "the interplay of theory, ideology, and practice in the production and interpretation of science" (p. 137). And she shows how "ideological presures . . . can be seen . . . as directly related to the commitment of modern science to a particular concept of masculinity" (p. 137).

Keller is famous for her biography of Barbara McClintock (1902-1992), the cytogeneticist who won the Nobel Prize in 1983 for work that had gone largely unacknowledged for 30 years. (McClintock discovered genetic transposition, the ability of genetic elements to move from one chromosomal site to another, in an orderly way. She worked with corn plants.) Keller finds in McClintock an example of a scientist who was both highly respected among

fellow scientists (mostly male) and at the same time relegated to an obscure lab and largely ignored by fellow scientists (mostly male) throughout her career. She finds in McClintock an example of a scientist who was readily recognizable as a scientist, who knew the language and methods of science, but who lived by "a vision of science premised on order rather than law, on respect rather than domination," who practiced what Keller calls "dynamic objectivity," and who had a "willingness to 'listen to what the material has to tell you'" (p. 138).

In the most captivating, the most poignant, insight in her book, Keller points out:

> In a science constructed around the naming of object (nature) as female and the parrallel naming of subject (mind) as male, any scientist who happens to be a woman is confronted with an a priori contradiction in terms. This poses a critical problem of identity: any scientist who is not a man walks a path bounded on one side by inauthenticity and on the other by subversion. . . . Only if she undergoes a radical disidentification from self can she share masculine pleasure in mastering a nature cast in the image of woman as passive, inert, and blind. Her alternative is to attempt a radical redefinition of terms (p. 174-175).

The point here is that when a woman involves herself in scientific and/or technological endeavor within the Baconian ideology, she must work out her personal identity as a woman (who is doing what is, quintessentially, masculine work) or she must work out a conceptualization of science (other than one of "'putting nature on the rack and torturing the answers out of her'" (p. 174)) or both. Men scientists bear no such burden. For women,

> Nature must be renamed as not female, or, at least, as not an alienated object. By the same token, the mind, if the female scientist is to have one, must be renamed as not necessarily male, and accordingly recast with a more inclusive subjectivity. This is not to say that the male scientist cannot claim similar redefinition (certainly many have done

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so) but, by contrast to the woman scientist, his identity does not require it (p. 175).

Examples such as McClintock and Keller help to broaden the horizons and increase the likelihood of success for women in science and technology today.

The final story of this chapter, "Mathematics, Education, and Gatekeeping," is important for educators and pragmatists, and it is important for the sake of perspective. The threads of the preceding stories are woven into it, and its threads are woven into them.

Mathematics, Education, and Gatekeeping

One of the most visible barriers to an engineering (or any technical or scientific) career is mathematics. Lucy Sells (1973, 1992) has called mathematics a "critical filter in the job market" for women. Access to engineering (and other technical and scientific careers) is limited for women and other marginalized groups on the basis of mathematics test results. The mathematical competence of women has been the subject of extensive study, from Benbow & Stanley (1980a, 1980b) to Fennema (1977, 1980, 1981, 1984, 1985, 1990, etc.) and many others; from biennial reports on *Women and Minorities in Science and Engineering* by the NSF to Hacker (1983, 1989) and Tobias (1978, 1990).

While many women have done mathematics and science well, the common perception is that women are not interested in mathematics and science and don't do well in these areas of study or specialty. The NSF (1990) has reported that women score lower than men in mathematics and science on the SAT (Scholastic Aptitude Test) and the GRE (General Record Examination), enter science and engineering careers in numbers

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disproportionately less than men, and, of course, are paid only 70% of the salary of men in comparable positions and with comparable experience. Most striking of all, only 8% of engineers are women (NSF, 1996).

Research on Women and Mathematics Education

Sex differences in behavior and performance constitute a strong focus of study from the beginnings of psychology and especially in the 1970's and early 1980's. Characteristics and abilities of all sorts were examined in attempts to draw up generalizations about women and men and their differences (Maccoby & Jacklin, 1974). Research into sex-related differences in mathematics achievement explored and attempted to interpret the influence of several categories of variables, including:

- **cognitive** variables such as general ability, verbal ability, amount of time spent studying mathematics, number of math and math-related courses enrolled in, cognitive complexity of the mathematics tasks at hand, and spatial ability, including spatial visualization (Fennema, 1977,1980, 1981, 1984; Fennema & Sherman, 1977; Sherman, 1977; Tartre, 1990);

- **affective** variables such as confidence, anxiety, perceived usefulness of mathematics, perceived attitudes of important others, including mother, father, and teacher, attribution of success and failure (Eccles, 1985; Fennema, 1977, 1980, 1981, 1984; Fennema & Sherman, 1977; Leder, 1985);

- **educational** variables as single-sex schools vs co-educational schools, sex-role stereotyping in mathematics textbooks, differential attention

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given to girls and boys during classroom teaching (Fennema, 1977, 1980, 1981, 1984, 1990; Leder, 1985);

- **biological** condiderations such as hormone levels, genetic predisposition, and brain hemishpere orientation (Fausto-Sterling, 1985; Sherman, 1977); and

- **socio-cultural** factors such as informal mathematical experience, sex-related differences in behavior, stereotypes about appropriateness of mathematics study, and peer group valuing of games and occupational ambitions (Eccles, 1985; Fausto-Sterling, 1985; Fennema, 1990; Fennema & Peterson, 1985; Fennema & Sherman, 1977; Maines, 1985; Schonberger, 1980).

Among the cognitive variables, visuo-spatial ability has been the topic of a great deal of speculation and investigation (Fausto-Sterling, 1985; Fennema, 1977, 1980, 1981, 1984; Fennema & Sherman, 1977; Leder & Fennema, 1990; Maccoby & Jacklin, 1974; Schonberger, 1980, 1990; Sherman, 1974, 1977; Tartre, 1990). A consideration of research on correlations among visuo-spatial ability, mathematics achievement, and sex is illustrative of the work done in the investigation of sex differences.

Lindsay Tartre's impressively comprehensive treatment of this topic is described here as an example of the kind of scientific story-making that contributes to the "sex differences story." In her 1990 contribution to Fennema & Leder's *Mathematics and Gender*, Tartre begins with a discussion of the various "spatial skills" that have been enumerated, described, operationally defined, and even "measured." She discusses the identification of each type of spatial skill, describes what that skill is and how we use it,

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names the people involved in the early development of instruments to test for that skill, shows specific examples of items used in assessing that skill, and briefly presents the results of early tests. She also considers alternative positions on the information she has presented, giving explanations of her incorporation or exclusion of that information in this section of her paper. She organizes all of this into a taxonomy of spatial skills, the two primary divisions of which are "spatial visualization" and "spatial orientation". Then, after a discussion of sex differences, both in spatial skills and in mathematics achievement, she describes two studies intended to explore correlations among sex, spatial skill, and mathematics achievement.

One of Tartre's studies is concerned with spatial visualization; the other is concerned with spatial orientation. Spatial visualization is the set of spatial skills most familiar to us from casual references; it involves the ability mentally to manipulate objects through rotations, reflections, and translations; and to transform a 2- or 3-dimensional figure into other renderings of the figure in 2- or 3-dimensions. In contrast, spatial orientation involves imagining oneself in a different perspective with respect to an object under consideration. The "Hidden Figures Test," which measures spatial orientation ability, is not unlike the "Where's Waldo?" activities on the Sunday comics pages. Success with this activity has been considered to be associated with an "analytic" cognitive style, or "field independence" (see also Fausto-Sterling, 1985; Sherman, 1974).

In both of the studies Tartre discusses, four groups of subjects were chosen such that there was a group of girls with high spatial skills, a group of girls with low spatial skills, a group of boys with high spatial skills, and a group of boys with low spatial skills. With the spatial visualization study,

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"[a]lthough no overall difference between the two spatial skill level groups was found for the number of problems solved correctly, differences in patterns of behavior were detected" (p. 47). With the spatial orientation study, "[n]o significant difference was found overall between males and females in [spatial orientation] skill or in mathematics achievement. No overall gender difference was found in the number of correct answers. Two significant differences were found in how females and males solved the problems" (p. 52). Tartre goes on to observe that in general, "[s]patial skill does seem to be more related to mathematics performance for females than for males. In both of these studies, females who scored high on a test of spatial skill achieved as well as, and in some cases much better than, the male groups on mathematics achievement and measures of many other strategic variables. However, females who scored low on a test of spatial skill experienced difficulty in accomplishing many tasks involved in solving mathematics problems" (p. 57). Tartre concludes that these studies do not support the conjecture that males have better mathematics achievement due to possession of higher levels of skill in spatial visualization or spatial orientation. Rather these studies suggest a need for reassessment of the *conjecture* that correlations might exist *at all* among sex, spatial skills, and mathematics achievement. Nevertheless, one continues to hear and read of studies of gender differences in visuo-spatial ability. The fact that such studies persist implies a story that stands in contrast to the actual findings of Tartre's work.

Stratification and Gatekeeping: Ideology Under Development

In her book, *Pleasure, Power and Technology*, Sally Hacker (1989) finds in the military a powerful force shaping the experience and the exclusion of women, and indeed the definition of the feminine. Over 5000 years ago, she reports, groups of men began to promise protection in exchange for food and other services. "Formal, differentiated military institutions such as armies soon emerged" (Hacker, 1989, p. 59). These institutions interacted with society, influencing ways of seeing things, ways of doing things, ways of organizing things, and attitudes about just what ought to be done at all. Whereas the early protection men lived among the women, children, and old men who provided food and services to them, things were to change profoundly. As the scale of military institutions and their promises of protection grew to include larger regions, the women, children, and old men, usually out-numbering the soldiers, traveled with the army. This presented "problems" of organization and logistics. Stratification of people by gender and by service provided was established, and eventually women, children, and old men were excluded altogether. This exclusion was reflected in society at large. As the military excluded women from the craft and service functions they had formerly fulfilled, women began to be excluded from civilian crafts and handiwork as well.

To fill the needs of the military for specialized functions, men only were given training that incorporated strict military discipline. Education in the creation and use of technology for the military was provided by engineering schools, which would later became the famous polytechnic institutes of Europe. "Engineering served as the technological arm of military institutions. Indeed, engineering was an exclusively military calling until the

eighteenth century" (Hacker, 1989, p. 61). Engineering education emphasized discipline, self-control, hierarchical organization of people and of knowledge, and the exclusion of women. It emphasized "utilitarian and scientific principles" rather than the classical subjects of "Greek, Latin, and moral philosophy" (Hacker, 1989, p. 62). Mathematics, it was argued, disciplines the mind just as military drills discipline the body (Hacker, 1989). Numerical grades established an "objective" ranking of students. A hierarchy of masculinities was thus defined.

These ideas were brought to the United States in 1817 by Sylvanus Thayer, superintendent of the first engineering school in the United States, the fifteen year old United States Military Academy at West Point. Sent by George Washington to study the methods used at the Ecole Polytechnic in Paris, upon his return, he imposed a regimen of constant activity, observation, discipline, grading, competition, and efficiency (Hacker, 1989; Postman, 1992). In 1821, these militaristic reforms were introduced at Harvard by George Ticknor. They subsequently spread throughout education and to industry as well.

At the same time military-like processes were being established throughout education and industry, two other radical reforms were afoot in the land. One was the professionalization movement (Bledstein, 1976). The other was the industrial revolution. The professionalization of engineering followed a pattern typical of the professionalization movement of the nineteenth century (Bledstein, 1976). Struggles took place over the definitions of engineering and engineering education, the identification of the traits of the ideal engineer, and the establishment of criteria by which to

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select individuals who would be given access to the field. Money and status were guiding issues of concern.

According to Hacker (1983), the power struggle in the professionalization of engineering was mainly between the "shop culture" and the "school culture" of engineering education. The shop culture placed emphasis on hands-on apprenticeship in which technical skills, primarily mechanical in nature, involving visual and manual understanding of machines, were acquired in a practical on-the-job environment. The school culture, emphasizing mathematics, physics, and chemistry, grew up largely in the land grant colleges of the midwest. Proponents of both the shop culture and the school culture appealed to arguments of democratic principle and quality of work in support of their respective positions on engineering education. While shop culture apprentices were hand-picked, typically excluding women and Southern and Eastern European men (and Blacks, American Indians, and Asians), the contention was that there was no unfair exclusion of men who had had little opportunity to study mathematics. With school culture engineering students, again typically including only white male Protestants, the contention was that admission on the basis of "objective" mathematics testing was more fair than an informal hand-picking of apprentice engineers. The school culture, well-funded due largely to the Morrill Act of 1862, was able to accommodate large numbers of engineering students. Their emphasis on mathematics and science supported an increasing interest in the development of control technologies and electrical and chemical technologies. The students of these programs emerged with prestigious college degrees which differentiated them from "mere" shop workers. Professional organizations united this new breed of engineer,

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providing a forum from which to specify rigid standards of engineering education and selective admissions to programs, and to monitor and influence the status and salaries of engineering professionals throughout industry. Hierarchies of engineering support jobs, requiring decreasing emphasis on results of mathematics testing, were established.

Still, there was concern about the match between schooled engineers and engineering jobs. Charles Mann, a prominent engineering educator, investigated the question of whether the ability to pass tests in school subjects was correlated with ability to do good work as an engineer. He subsequently published *A Study of Engineering Education*, commonly referred to as the *Mann Report of 1918*. Mann was unable to find correlations between test and class grades and the job performance reported by employers of specific graduates of engineering schools. Nevertheless, "Mann favored retaining mathematics requirements and tests," strictly as instruments of discipline and control and, of course, exclusion of the "unworthy" (Hacker, 1983, p. 47).

Meanwhile, as institutionalization of a military-like engineering profession was solidifying, science and the industrial revolution were inspiring significant new inventions approximately every tens years. Consider the following dates of inventions (Postman, 1992):

1765	steam engine
1806	power loom
1816	stethoscope
1830's	photograph, telegraph
1840's	rotary power printing
1850's	machine-tool industry, opthalmoscope, laryngoscope
1860's	typewriter, transatlantic cable
1876	telephone
1895	X-ray, wireless telegraphy

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All these inventions, of course, opened the way to new industries, new technologies, new science. The rising number of degreed engineers was welcome in this setting. And women were not among them.

Historical Perspective: The Entrenchment of Numeracy and Rational Logic

Since the 1630's when Galileo emphasized the importance of empirical observation of "objective facts" and Descartes emphasized the value of abstract mathematical reasoning, the emphasis on mathematics and formal logic in human endeavor has increased and become deeply entrenched (Hacker, 1983; Toulmin, 1990). Patricia Cline Cohen's (1982) history of "numeracy" in early America delineates a progression from pre-literate times, through the times of the rise of the importance of literacy, into the times of the power of numeracy, when concerns with counting and calculating, efficiency and statistical significance, express our perceptions and desires about our world and our place in it.

Numeracy, sometimes called mathematical literacy, has not always been considered as important as it is today. In fact, neither mathematical achievement nor visuo-spatial ability has always been associated with women's exclusion from participating in the activities of their choice. Cohen shows us how the importance of numeracy developed from colonial times to the twentieth century in the United States, and she points out women's presence in/absence from that process. She writes:

> at various times some abilities have been more closely associated with mathematical skill than at others. For example, eighteenth-century arithmetic was largely conceived of as memory work, whereas nineteenth-century arithmetic was reformulated to rely on inductive reasoning. Failure to thrive in twentieth-century geometry is often blamed on poor ability in spatial relations, but those nineteenth-

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century educators who claimed that geometry was impossible for women to understand would never have assumed females to be deficient in spatial relations, for that would have been inconsistent with women's demonstrated talents in constructing garments out of flatgoods without benefit of patterns. Instead, they put the blame on insufficient abstract reasoning power... (1982, p. 8)

Mathematics was not taught at all in colonial times in the United States. As a subject of study, it was gradually introduced to boys, but generally not girls, in support of commercial efforts. Later, the study of mathematics came to be valued for the mental discipline that was associated with it. As college engineering programs were instituted in the late 1800s and early 1900s, mathematics test scores assumed a gatekeeping function. Girls, traditionally not having been as rigorously schooled in mathematics, came to be thought of as less able to think mathematically than boys.

In the 1700s, mathematics expertise rarely extended beyond the arithmetic that was useful for commercial purposes. Women were excluded from commercial activity to a great extent before the Revolutionary War, partly because it was considered a man's domain and partly because the colonies at that time were mostly rural and people lived in a subsistence economy rather than maintaining great commercial interests. When arithmetic was taught, it was taught to older students, in advanced classes, which generally did not include women. The pedagogical methods involved the learning of rules and the memorization and use of tables of "facts". It was generally thought that the "memory work" required for the mastery of arithmetic was beyond the capabilities of women.

Later, as it began to seem desirable that women should be able to do bookkeeping for the household or the family business, arithmetic was taught

to girls in schools. In the 1820s, methods of teaching arithmetic were revolutionized by Warren Colburn, who published textbooks which emphasized the meaning of and reasoning behind the operations of arithmetic. The study of arithmetic assumed a double function: that of a practical commercial skill; and that of a rational, logical mental exercise. The history of girls' absence from the sphere of advanced formal education ironically contributed to the formation of the belief that women were not capable of reasoning logically about mathematical ideas, just as pedagogical methods were making mathematical ideas more accessible and just as women were demonstrating the ability to keep the financial records of families and businesses.

Perhaps the history of women's relative absence from the world of mathematics, science, and the technical contributes to the formation of a contemporary belief that women are inferior to men in (for instance) visuo-spatial ability, just as the availability of visual imagery has made mathematical, scientific, and technological ideas more accessible, and just as women are demonstrating their abilities to participate successfully in the abstract and logical realms of mathematics, science, and technology. Women today participate in many activities of which they were formerly thought incapable. Clerical work is one such activity (Gaskell, 1987); manufacturing jobs of all sorts constitute another. Our experience of and activity in our world today is undergirded by a facility with numbers and mathematical concepts. Of course women can learn mathematics. Of course women can be engineers and computer scientists.

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CHAPTER 3

RESEARCH METHODOLOGIES AND PROCEDURES

The conflict between positivist and postpositivist research methodologies is mirrored in this study. Computer science and engineering, and their practitioners, are steeped in the mathematical methods of the physical sciences. These are the Baconian methods--modern science. They are the methods which have been embraced and adopted by positivist social science. Postpositivist methods of inquiry have sought to recognize, formulate, and honor other useful and meaningful systems of knowledge as well. While my study is situated methodologically in the latter category, it is concerned with the former category, the modern, mathematical realm of the physical sciences, the technical realm. There is a tension in this study that is associated with my involvement at the boundaries of these methodologies. This underlying tension is part of what drew me to this investigation.

The locus of concerns in this study extends beyond the reach of phenomenology since the study is not focused on the distinction and naming of essential qualities and characteristics, or with generalization. However, a hermeneutic sensitivity to contextual dependencies, nuances, and histories is (and was) central to my attempts at insight, interpretation, and understanding. The study is ethnographic in the sense that it is concerned

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with the culture of engineering and computer science. It is phenomenological in the sense that I am interested in how women computer scientists experience this culture. It assumes a feminist standpoint (Hartsock, 1983; Harding, 1986, 1991, 1993) in that it establishes women computer scientists' experience as the starting point of the study, and aims to describe and interpret the technological realm from the perspective of these women's lives. It gives postmodern consideration to allowing the voices of the participants to be heard in multiple readings and within complex discourses, interwoven with personal, social, and historical influences and outcomes. It makes use of the deconstruction of concepts and issues relevant to gender, science, engineering, and technology. The design of the study, as it emerged in its course, encompasses elements of all these philosophies and methodologies, though the study does not fit neatly into any single one of these methodological categories. The study was conducted by means of interviews. Interviewing is a major data gathering technique used in many qualitative methodologies, including phenomenology and ethnography (Bogdan & Biklen, 1992; Gay, 1987; Glesne & Peshkin, 1992; Kvale, 1992; Lather, 1991a, 1991b; Mishler, 1990; Oakley, 1981; Patton, 1990; Spradley, 1979; Thomas, 1993).

Prior Ethnography

This research project arose out of my own experience. I am myself a woman for whom the study of mathematics was *not* an obvious technical-career *barrier*: I have studied and taught mathematics and computer science with some success. However, having grown up female in the '50s and '60s, in a working class family, my being female *was* a strong technical-career barrier,

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albeit a less-than-fully-conscious one. My expressed interest in being an elementary school teacher was encouraged from early childhood and was realized from 1972-80. As the 1980s drew near, and I had accumulated an ever-increasing amount of formal education in mathematics and computer science I also became increasingly aware of technical-career options that paid better and were held in higher esteem than the teaching career I had chosen. I suspended graduate study in computer science and sought a computer systems/programming/analysis job in an engineering research environment, believing I would benefit from the opportunity to experience for myself what people with computer science education do in industry. Over the course of the six years that followed, I lived the role of the "observant participator" in an informal "prior ethnography" to what was to become this study. Since leaving full-time employment in an engineering environment, I have been in graduate school, first to complete my M.S. in computer science, and now to work on my Ph.D. in educational technology/cultural studies in education. I have been supported throughout by a Graduate Research Associateship with University Technology Services, the organization that provides computing services of all types to the entire Ohio State University community. (There I have designed and taught workshops on the use of the Unix operating system; I have worked with an IBM 3090/600J mainframe computer system (running the MVS/ESA operating system), doing installation and maintenance of application software used throughout the university for instructional and research purposes; I have provided consultation services to users of the TSO and Wylbur user interfaces to the MVS system, the magnetic tape services, the programming languages, the statistical analysis software systems, and the other software systems available under MVS; and I have

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supported users of both communications systems (such as email, newsgroups, gopher, and World Wide Web browsers) and statistical analysis systems (such as SAS and SPSS) on computer systems such as Unix, Windows, and the Macintosh systems.)   I continue to be in contact with many of my former computer science and engineering colleagues. And I continue to be involved in technical endeavor while in graduate school. These continuing relations cannot but contribute to the shaping and re-shaping of my understandings. Thus, it could be said, my informal prior ethnography is ongoing.

Early in this prior ethnography I came to a profound and formative insight which is described in the following excerpt from my later journals:

> What [a female computer professional feels she has] noticed lately is that the men she works with are "confrontational." She goes on to explain that even when she is in a position of expertise, and they are distinctly not, they will contradict her statements of fact, never returning later to apologize for what they surely must have come to realize was an error, and apparently never aware of the disruptive and intrusive nature of their behavior. She also finds that in meetings and even more so in smaller discussions, her comments and insights go entirely unacknowledged, as if they'd never been spoken. Yet at a later time, an idea she had advanced in the group will be put forth by one of the men who'd been present, as one of his own, with apparently no awareness that the idea had come from her. She feels intruded upon and trampled. Every woman I know in science and engineering seems to eventually share this experience.

This insight led me to wonder what else women could report about engineering: how it is done, how it is to be a woman in this male-dominated realm, how the technocentric worldview is shaped and lived, how it is experienced. Surely the experience of my prior ethnography informs the stories I tell from this study. And this study would lend structure to the telling of stories from my prior ethnography. Each enriches the other. They

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are intertwined at emotional and rational levels though not explicitly at the level of the interview data.

Design of Study

This study is concerned with making visible, understanding, and interpreting particulars rather than formulating, hypothesizing, and testing generalities. It does not share with modern science a preoccupation with prediction, repeatability, statistical significance, or the "discovery" of essential qualities of the experience of women in technology. Rather, this study aims to tell stories from the experience of some computer scientists who are women and who are currently employed in technical research and development efforts.

During coursework in the methods and philosophies of doing qualitative research, I did pilot study that foreshadows this research. In the context of pilot study, I observed and interviewed personal friends who are women engineers. They later put me in contact with other women who might be interested in participating in the study. The pilot work was useful in my formulation of interview guides for the study. It also led to the formulation of a "grounded survey" (Bogdan & Biklen, 1992; Fetterman, 1989; Goetz & LeCompte, 1984; Jung, 1993) which I used in the introductory phase of the study. In addition, the pilot study efforts led to clarification and refinement of my research focus. And the pilot work gave me familiarity with qualitative research methods. In this section, I describe the methods and procedures I followed in conducting the research.

Sample

I contacted women computer scientists whose names I had been given by women computer scientists I know, including the women who involved themselves in pilot study with me early on. Patton (1990) calls this type of purposeful sampling "snowball sampling." My intention was to conduct my research with women I had never met, so as to "start with a clean slate," that is, not having specific prior knowledge or understanding of the participant's experience. In retrospect, I think this concern was unnecessary, although a study with women I already knew would have been a somewhat different kind of study.

In my prospectus, I described my ideal participant for this study as a woman who is reflective and articulate. I went on to say:

> She will be "seasoned" in life, if not in career, i.e., she may be fairly new to her career, but I do not expect most women as young as mid-twenties to be in possession of the life experience I wish to draw upon in this study. I expect to prefer over others a woman who is accomplished in her field of expertise, who has completed graduate study, who is successful by the traditional standards, who is an insider, but not one who is in the stage of winding down her career. My ideal study participant will have a broad perspective. She will have involvements outside of science and engineering/technology that give her access to a non-empiricist view of the world.

In all, I interviewed 20 different women. Their ages ranged from 20s to 50s. Their education ranged from the single BS in computer science, through multiple degrees including one in computer science, to the MS in computer science. They worked at six different companies, all of which are involved in computer supported technological development projects. All of these women are white.

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Initial Contact

My initial contacts with the women were usually by email. In some cases, I was given their email addresses after they had given permission to be contacted. In other cases, the women contacted me after hearing about my study. Via email, I obtained their phones numbers. In two cases, women I had just met agreed to meet with me in person each for a single long interview. These two women worked at places from which I did not interview any other women.

First Interview

My first interview with each of the participants was a half-hour audio-taped telephone interview, except in the two cases mentioned above. This interview was usually very structured and yielded very useful data. In addition, it provided an opportunity to get to know the participant and to let her get to know me. My intention was to give the participant an idea of what I am like and what kinds of questions I wanted to ask, while allowing me to gauge whether she seemed like a reflective and articulate woman such as I was hoping to find for the study. The decision whether or not to continue the interview in person at a later time was made after the telephone interview. The interview guide for the telephone interviews is included as Appendix B.

Questionnaire

After the telephone interview, I sent the participant a letter describing how I expected to proceed with my study, along with a questionnaire grounded in the experience of pilot study and intended to collect some demographic data as well, and a consent form (These are attached as

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Appendix A). The demographic data I sought on the questionnaire included name, address, and phone; age range; graduation dates, academic majors, and highest degrees; publications, special honors, and professional affiliations; and career history. I also asked each participant to chose a pseudonym by which I would refer to her throughout my writing. I wanted to collect such information in a systematic way, and I didn't want too much interview time to be spent on this routine information.

The other questions on the questionnaire were grounded in my analyses of both pilot study and prior ethnography. They were intended to be introductory, to give the participant a sense of the kind of questioning to expect from me, and to give me some sense of the participant's personal stance. I hoped that perhaps it would even stimulate the participant's thinking about specific things that I would want to discuss in the interviews. The "grounded survey" section of the questionnaire consisted of just five questions. These questions constituted a cursory exploration of the participant's own sense of agency with respect to her technical work, and her commitment to the notion of scientific objectivity.

Subsequent Interviews

After the first interview (by telephone) most of the women were interviewed again, in person, for approximately two hours. Most of them returned the paperwork described above at the beginning of this interview. The women left me with different impresions when interviewed in person rather than over the phone. The telephone interview by itself did not serve as an adequate screening mechanism for deciding who to continue interviewing, though it provided a good way to make introductions and get

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started exchanging information. Often, perhaps because a mutual trust was established in the face to face experience that could not be established through the mediation of telephone technology, the women seemed to be more interesting in person than over the phone.

The subsequent face-to-face interview was more in-depth and open-ended than the first (phone) interview. It too was audio-taped (A list of the tapes is included as Appendix E). The interview guide for subsequent interviews (Appendix C) consisted of questions that followed numerous threads, some of them directly relevant and some of them less relevant to the particular experience of a given participant. Some of the points of discussion were inspired by specifics from an earlier interview, some were follow-ups to issues on the questionnaire, some arose from the literature, and some were related to my ongoing/emerging analysis and interpretation of the data I had collected so far.

Workplace Observation

Most of the women I interviewed were from just two companies; almost twice as many were from these two companies than from the other four companies combined. (The companies are described in a section below.) I visited these two companies, and one other (companies A, B, and F), to do workplace observations. I felt that an important factor in my understanding of the women's stories was my sense of the physical site where they work. In pilot study, I "shadowed" a woman engineer on her job for a single period of two hours. Because it seemed redundant, I felt it was unnecessary to do such a lengthy observation of the participants in the study. But I did think it useful to note the atmosphere of some of the places where women in the study

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spend a minimum of eight hours a day all year 'round. Does the place have a comfortable 'feel' about it? Is it comfortably heated and cooled and ventilated? Is it clean, well-lit, and pleasantly painted and decorated? How much physical space is allotted for each worker? Are there sharp distinctions in the comfort afforded to workers of varying status? How does everybody dress? Is food and drink conveniently available on the grounds? Does the company provide medical, recreational, fitness, or childcare facilities? Site visits and observation were usually done in connection with the interviewing process.

Profiles

From the twenty women in the study, I chose five to study particularly closely. I summarized their respective "stories," creating profiles, which I include in the next chapter. I discuss these profiles further in a later section of this chapter. The profiles were instrumental in focusing my data analysis.

Member Checks

The profiles I wrote, summarizing the information I had about five of the women in the study, also provided material to use in seeking confirmation that I understood what the women had told me. Unice Teasley (1996) refers to this process as a "reality check;" Guba & Lincoln (1989) call it a "member check." I sent each of the five women the profile I had written about her, asking her to confirm my understanding and/or make corrections or comments about how my profile corresponded with her own understanding and recollection of our conversations. (See Apendix D for this

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communication.) This process gave me assurance that I had represented the women fairly; although invited to do so, no one suggested any corrections.

Peer Debriefing

Throughout the course of this project I have met regularly with my "writing group," a group of graduate students who provide research and writing support to each other on an informal basis. The members of this group provided feedback as I grappled with my interview data, its meaning and significance, and the task of piecing it together into coherent/ meaningful/useful stories. My advisor also served this function, referred to as "peer debriefing" by Woodbrooks (1991). The peer debriefing process stimulated and nurtured the emergence of insight through collaborative reflection, challenge, clarification, grounding, and, ultimately, knowledge building.

Data Discussion

I began my data analysis by composing a profile, a summary "story" of what I know, about each of five women in the study: Amber, Dale, Eileen, Kate, and Tamra. I chose these five for various reasons. They seemed to represent the range of variety among the women I had interviewed in a number of ways. They came from four of the six companies from which there were women in the study. Their ages ranged from 20s to 40s. Their career and educational backgrounds were varied, as were those of the entire group of women I interviewed. Most important, they were articulate and reflective; they had many interesting things to talk about. I related to some of their stories, and I didn't relate to others of their stories. They made striking

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points in talking about their own histories and experience. I liked these women. I was touched by their stories.

I was particularly interested in the women who had done graduate study and worked among others who had done so, since that was my own experience in the technical realm. I was also interested in how directly they had moved from high school, through college (and graduate school), and into their technical careers and their current jobs. I was interested in what their companies were like, what sorts of interactions and collaborations they had with their colleagues, and what kinds of education their co-workers had as well. Beyond that, I was interested in what kinds of people they were aside from their technical personas, what their childhoods and families had contributed to their current relationship with the world, and how they spend their time outside of work.

Because each profile was tailored around the salient issues evoked in interviews, the profiles did not follow a fixed format, nor did they cover all the same points. But each profile brought together for me the most interesting points, issues, quotations, or experience from the interviews of a specific woman. The profiles helped me to see the variety of experience among the women in the study, not a simple list of commonalities. It was clear that the most striking pattern in the data was that there was no pattern. The contradictions, paradoxes, and conflicts among the stories of the women in the study and within the stories of specific women emerged as an organizing theme. I began making lists of these, and wrestling with ways to sort through them, group them, and elucidate them. Suzanne Damarin (my advisor) observed in conversation one day that if the women are living it, then it isn't really contradiction. The family nurturer, the avid athelete, the

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competitive technology developer, the nature conservationist--all these subjectivities can be bundled together--and, not only often, but usually, are-- within a woman such as the women computer scientists in this study. Gradually, the categories that I explore in Chapter 5 emerged.

The Companies

Eight of the women I interviewed worked at company A. The computer scientists in their company are responsible for the design, development, and maintanence of large-scale databases of technical information and the query languages that are used to access this information. These systems are designed and maintained across numerous computer system platforms and access schemes 24 hours a day worldwide. The technical information contained in the databases is provided by scientists employed by the company.

Five of the women I interviewed worked at company B. The technical employees in their company are almost all computer engineers and scientists with masters or doctoral degrees in the field (though they may not have originally started out as computer science majors as undergraduate college students). Their company designs, develops, installs, and maintains complex communications systems worldwide. Many of the inventions of this company are famous and are studied at theoretical levels in colleges and graduate schools. The complexity of the systems with which they are involved includes massive databases, artificial intelligence systems, elaborate systems of software, and hardware systems consisting of numerous components, all working together transparently and "cooperatively."

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Two of the women I interviewed worked at company C, which is a world leader in providing innovative computer on-line services. They are among the most technical of the computer scientists and computer specialists in their company. They design, develop, implement, and maintain the in-house software environment within which others in the company develop the software that will interface with customers and that will be used by customers.

Three of the women I interviewed worked at company D. Their company is a research and development company providing technical scientific and engineering solutions for myriad applications around the world. A large percentage of the employees there have graduate degrees in technical fields. While the use of computers is prominent in the work of the company, it is not central to the company's image. The women I interviewed apply their computer expertise to various technical projects, according to the needs of the particular project they are associated with at any given time.

One woman I interviewed worked at company E, a software company through which she had been hired to work in the computer systems and support division of a very large organization in the aeronautics industry. The work involved applying cutting edge computer science hardware and theory to aerodynamics simulations. The results of the work are potentially applicable nationwide and worldwide, though they remain at the theoretical level at the present time.

One woman I interviewed worked at company F. She and her colleagues were responsible for the implementation and support of large systems of computers in an institution of higher education. They provide access to leading edge computing and computer-supported communications

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systems and software. They also customize, implement, and maintain distributed computer security systems, with which the woman I interviewed was involved.

The Women

Six of the women had their masters degrees in computer science, and one of these was a doctoral student in computer science. Another woman was working on her MS in computer science, and yet another was working on her MBA and already had her MS in physics. Nine of the women were in their 40s or 50s; eleven of them were in their 20s or 30s. Eight of the women had had other careers before embarking on their current technical career. At the time of the interviews, six of the women held some sort of supervisory role at work.

Table 1 summarizes the women's ages and educational backgrounds. Table 2 summarizes some details of the women's company affiliation and career history. In both tables the women are identified by the pseudonyms they chose for reporting purposes. Following the tables, Chapter 4 provides the five profiles or summary "stories" with which I began to investigate and sort through my interview data.

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Name	Age	Post-Secondary Education
Cecilia	40s	MS Computer Science, BS Mathematics
Justine	30s	MS Computer Science, BS Industrial Engineering
Michelle	40s	MS Computer Science, MS Industrial and Systems Engineering, BA Mathematics Education
Amber	40s	MS Computer Science, AS Computer Technology, BA Psychology
Dale	40s	MS Computer Science (in progress), BS Computer Science, MA Human Learning, BA Psychology
Kate	20s	PhD Computer Science (in progress), MS Computer Science, BS Engineering Physics
Ann	50s	MS Computer Science, BS Statistics
Erin	30s	MBA (in progress), MS Physics, BA Mathematics and French
Helen	30s	BS Computer Science, BS Journalism
Stella	20s	LMT (in progress), BS Computer Science
Kathy	40s	BS Computer Science (in progress), BS Chemistry
Tamra	20s	LMT (in progress), BS Computer Science
Sara	20s	BS Computer Science and Mathematics
Eileen	30s	BS Computer Science and Fine Art
Marie	40s	BS Computer Science
Amy	40s	BS Computer Science
Chris	30s	BS Computer Science
Jane	30s	BS Computer Science
Kay	30s	BIE Industrial Engineering
Gladys	40s	BS Computer Science (in progress)

Participants in the study, loosely grouped by amount of education, directness of the path from high school to the technical/computer science career, and amount of experience in their field. (LMT=Licensed Massage Therapist)

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Table 1. Participants and Education

Name	Company	First Career? / Other Careers	High Rank?
Cecilia	B*	1st	Manager
Justine	D*	1st	
Michelle	B	teaching	Manager
Amber	B	substitute teacher, Head Start, day care manager, factory worker	Manager
Dale	B	social work with mentally retarded, teacher of severely mentally handicapped	
Kate	E*	1st	
Ann	B	raised children to adulthood, ran office for husband's business, post office	
Erin	D*	1st	
Helen	A	journalism	
Stella	A	1st	
Kathy	A	secretary, administrative assistant	
Tamra	A	1st	
Sara	F*	1st	
Eileen	C*	1st	Director
Marie	A	army	Supervisor
Amy	A*	secretary	
Chris	C*	1st	Supervisor
Jane	A*	1st	
Kay	D*	1st	
Gladys	A	clerk, administrative assistant	

* indicates this woman has worked in a technical/computer science capacity previously in at least one other company.

Table 2. Participants and Professional Experience

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CHAPTER 4

PROFILES OF FIVE WOMEN

The individual stories, or profiles, of five of the women in the study are presented in alphabetical order in this chapter: Amber, Dale Anthony, Eileen, Kate, and Tamra. Each profile is different in format than the others; the profiles do not conform to a common structure. Nor are the contents of the profiles standardized. Each is tailored around the salient issues that arose in conversation with an individual woman. Another influence on the format of the profiles, however, comes from my peer debriefers, my writing group. While my own inclination had originally been to present the profiles in narrative, my writing group persuaded me to try to work more with direct quotes, to build my stories around noteable quotations. As a result, the profiles range from almost entirely narrative to almost entirely quotations. One last influence on the form of the profiles is my own thinking, as ongoing reflection and analysis proceded. Thus, for instance, at times, I was concerned with the reasons a woman might want to do this technical work, while at other times I was fascinated by a woman's speech patterns, and at other times I was concerned with personal influences such as family background.

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Amber

Amber refers to herself as a coach (rather than supervisor or manager) of a software development team/group. Wanting to "help people" has always been a conscious theme in her work preferences. It is important to her to have her office door open and to be accessible to those with whom she can facilitate getting problems solved, especially members of her group, for whom she provides support and guidance. She also finds satisfaction in the planning process and design phases of projects, which involve sitting down with partners and customers to discuss and negotiate what is needed and how it might be accomplished.

Amber grew up on a 70-acre farm. She had four brothers: two six and seven years older respectively, and two six and ten years younger respectively (and no sisters). In a way she was an 'only child' in this family setting, with no confidant or peer. Her brothers are typical white men, she says. She feels that in some ways her whole life has been male-dominated. The older brothers bullied her and made fun of her, and the younger ones got "mothered" by her. The family's farm got put out of business when dairy farming regulations started requiring certain kinds of milk tanks that small operations like theirs could not justify or support financially. Her mother worked in the school cafeteria and her father had another job in town. They continued to have farm crops, animals, etc., just not on a large scale.

Education was important in their home. Most of Amber's aunts and uncles were teachers. Her mother had been valedictorian of her high school class, and would have gone on to college and a teaching career had the Depression not made that impossible. Amber herself has always enjoyed

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reading a lot, and in school she "studied hard and did well." Because her high school program was a college preparatory one, she took plenty of mathematics and science, along with all the other college-bound students, both female and male. She found her science teachers especially interesting, both in the classroom and in discussions outside the classroom. She did well in mathematics also, and "really enjoyed" the able freshmen calculus class she took her first year in college. Yet it did not occur to her to pursue a degree in science, mathematics, or something technical during those years. While her mathematics professor encouraged her to take more mathematics courses, she didn't think mathematics was relevant to anything she would do with her life. She majored in psychology, a program in which she found professors she enjoyed and admired, at a private university, and graduated in 1968. She immediately married a Mennonite man, a pacifist, and moved to a Unit in a poor all-Black section of Chicago that he was to serve. At the time, there was a shortage of teachers, and a nearby program offered free classes leading to certification, which she took advantage of.

Thereafter Amber substitute taught in Chicago Public Schools, worked with a Head Start program, taught kindergarten, and served as head teacher at a pre-school. She also did some factory work during those years. When, during her second marriage, she was pregnant with her son (now 14), she began to feel that her teaching was too emotionally demanding and frustrating, and that she wanted to reserve her emotional energy for her family. She was inspired to try computer science coursework after reading an encouraging article about women in computer science in *Woman's Day* magazine one day in the grocery store checkout line. Subsequently she earned an Associate's Degree in Computer Technology, and landed a job with

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her present company. She then proceeded to study computer science on a part time basis, and even taught an introductory computer science course at the invitation of one of her professors (in addition to her fulltime job, her studies, and her family responsibilities). She eventually qualified for and was admitted to the Master's program in Computer Science at Purdue University. Her company gave her a year off (with pay) to complete her Master's Degree in Computer Science in the late '80s. It was an "insane" year. She doesn't feel like she had the time to learn "very much of anything except how to hang in there, persevere, and prove to myself, once again, that I can take tests. And I got a 4 point." The Master's Degree provides her with a technical credential that is important within her company.

The Experience

Amber has been a technical manager since 1991. In her last group, there were about 25 people, and about half of them were women. In the past year, she has taken over a different group which had no women at all until she hired a woman contract worker. When she pointed out the absence of women in the group to the supervisor who had originally created the team, he shrugged and said he had never noticed.

In her current department there are 12 supervisors at the same level as she. There is one other woman supervisor besides herself, a woman with whom she does not feel very compatible. The manager the next level up from her is a man who happens to have a reputation for being somewhat difficult or at least not incredibly supportive. Recently Amber has been struggling to find ways to engage his support of her current project, which is important in terms of company revenues, but which is "not his passion."

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She has observed that he nearly always cancels their regularly scheduled status meetings. Recently he was an hour late for an hour and a half meeting in which they were to discuss her performance review, which, as it turned out, he had not even completed yet. She was angry and discouraged by this, and confronted him about his missing and canceling their meetings as often as he does. She feels she is being ignored because her project is not his passion rather than because she is a woman or because he may be somewhat put off or intimidated by her. Her discouragement is further complicated by a certain ambivalence on her part about having his commitment/involvement. In many ways she prefers his distance over the alternative, which is that if he is highly interested in a project, he interferes in the work of the project group and tries to exercise an unreasonable amount of control. His is the worst management style she has encountered in her 13 years with this company.

Amber feels this is a "wonderful job for a woman" in many ways, despite the problems she has experienced with her management lately. She feels "fortunate" to have a very good income, to work with wonderful people, to be surrounded by such diversity as her company provides, to work with fascinating and challenging technology, and to be involved in business decisions about millions of dollars. Besides these things being exciting, she doesn't have to "break [her] back to make a good living" and she is "not being oppressed terribly by anyone."

On the other hand, this can be a "tough field for a woman," Amber says. It is still very much male-dominated. Male members of minority and ethnic groups are better accepted than women much of the time. She feels she is under scrutiny, is doubted more. Sometimes it is difficult to maintain

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self-confidence because she "knows" others are "looking at [her] and wondering if they should have any confidence in [her] and unfortunately, that's hard--not to let it effect you."

In some ways, she holds back in her work, she says. She believes that this is not necessarily a bad thing; keeping opinions to oneself or refraining from restating somebody else's points in a meeting can be a contribution at times. But lately, she feels that something is blocking her from putting more of herself into her job than she would be happy with. This is probably related to her sense of a lack of full support from her manager, and she has been grappling with this.

She is keenly aware of not being "heard" at times, and distinguishes at least two different ways this happens. Sometimes she is "talked over." At other times, an idea she has put forth gets ignored only to be proffered later by a man who then gets credit for having a "good idea." Usually she speaks up calmly about this after the meeting in a one on one setting, pointing out that the good idea was originally hers, and asking, "Why can't I be heard?" She believes that you cannot make very much progress if you put people on the defensive by pointing out such things in public or in overly confrontational ways. She feels like she could be better at dealing with these incidences than she is now. She points out that an awareness of such things is necessary just to be able to survive the environment she is in. "Men can get away with a whole lot of shit that I can't get away with . . . not that I want to model my behavior after them because they're not behaviors that I particularly want to model anyway."

She "learned early on that [she] was never going to beat men at the game they were playing, . . . could never be the guys that they were, could

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never make the grade, would never fit in quite right." She even came to think of herself as not athletic, even though she was a cheerleader in high school (and jogs now). "It was tough 'cause I never fit in—I mean—I never . . . made the grade, I could never—you know—compete. So I found . . . my own style of competing, I guess, 'cause it *was* a very competitive family. But I could never compete in their style," she said. She believes, however, that perhaps she applies to her work situation some of the "skills" she developed in learning how to get along with her brothers.

She thinks that while some of the advantages and disadvantages of her work may be different for men than for women, there is a lot of overlap, and many of the advantages and disadvantages of the technical career are the same for women and men.

The Work Environment

There is a lot of diversity among the people working at Amber's company; this is not only accepted but encouraged. Perhaps this explains Amber's comment that, at least on a certain level, she doesn't feel like she is treated differently as a woman in a white-male-dominated realm. She likes to say her workplace is "like a little United Nations." Her company has emphasized an Affirmative Action program for many years and conscientiously employs women, African-Americans, Asians, and presumably Hispanics and Native Americans as well, though I didn't hear explicit references to these latter two minority groups. The public commitment to diversity is one of the most strongly-felt influences of the highest levels of management in her company. All employees are required to

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take Affirmative Action classes annually, to enhance awareness of issues of diversity.

While she is, somewhat regretfully, less politically active than at other times in her life, she is proud that her company provides opportunities for its employees to involve themselves in projects that are designed to provide service to the local community. She is on a steering team associated with, among other things, a project that is providing computer resources to certain schools for the improvement of communications among teachers, students, and parents. The system they have piloted and are now expanding is a voicemail system on which teachers can leave daily homework assignments (or other information or explanations) and pick up any questions, comments, or other messages from students or parents. This makes teachers accessible to students and their parents, and provides teachers a way of making important information readily available. The system is an application of voice recognition technology, a technology with which her department has expertise.

In 13 years with her company Amber has had many different assignments. She has easily found changes when she wanted them. Stimulating challenges have always been available to her. The company seems to strive to provide diverse opportunities for learning and growing all the way around. Employees are encouraged to take classes, and teamwork is emphasized over individual projects. Fifteen days of training are required of every employee each year.

While she feels there is "lots to like" about her work, she admits that she "could complain for three or four hours" sometimes too. There are times when the "bottom line" becomes the only consideration: people get ignored,

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quality suffers—you get into "rat mode." By and large, however, she is even-natured at work and patient with her co-workers, perhaps taking out any frustrations on the dog or family, she says.

"Double-Edged Sword"

Amber says that one of the most interesting classes she had in graduate school was a reading course on social and legal issues and responsibilities for computer scientists. Among the topics discussed were what social responsibility means, privacy issues, abuses due to someone's name being incorrectly associated with crimes or debts or etc., and copyright issues. Amber wrote a paper about the "Star Wars" (Strategic Defense Initiative) project, the commonly discussed aims of which were provably undoable, as she had learned in her graduate courses. She found it disturbing that decision makers saw fit to spend enormous amounts of public money for such destructive purposes as the Strategic Defense Initiative, a project depending heavily on computer technology. "I didn't know whether it was more frightening because somebody thought it should work, or because it wouldn't work. . . There was somewhat of a relief to know that it could never be done, but the frightening part was that none of those people that were passing the bills knew it couldn't be done; they thought it could be!"

Technology in general is quite expendable in some ways. Part of Amber says we could all live quite peacefully and happily in tents. Yet there are many ways in which technology is used for good. She remembers commenting to her manager at the time of the Challenger accident that she was glad not to be working on something as critical as the shuttle project, with responsibility for a life and death situation. He immediately pointed out

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that the 911 support provided by products she was involved with at the time is of critical importance in our day in dealing with emergencies. About the power of technology to stratify or fragment society, Amber says, "It's like any other discovery or invention that we have had since we discovered fire . . . Any of this stuff can be used for good or evil. It can be used to improve the lives of everyone in the world or it can be used to make some people richer and others poorer. . . It's a double-edged sword." For instance, at the time of the Oklahoma City bombing the Internet was "used for communication amongst all of those real right-wing type groups and I find that really disturbing . . . On the other hand, it's such a powerful tool for people to be able to communicate about good things."

Amber sees pros and cons to society's urge to have increasingly transparent technologies. The graphic computer interface and the associated mouse make it possible to know what is available on a computer and to execute a chosen program simply and easily. She also points out, however, that advanced users will not necessarily by well-served by overly simplified access; there must be provision for their exercising options simply and easily.

She cites the automobile transmission as another example around which to discuss transparent technology. The automatic transmission is simple and easy to use; one doesn't need to know what it is doing. On the other hand, a stick shift allows a driver to exercise control of how much power one gets out of the car, and when and in what circumstances to apply this power.

Amber cautions that we ought not let technology become "too entirely transparent because, again, then it almost takes on a life of its own. . . The more transparent things become, the more, I think, it encourages people to

think of computers as 'things that make mistakes.'" As she came to understand in her grad school class on social issues and responsibility, she believes we must strive to prevent circumstances in which "if the computer says it, it's true, and then all of a sudden it's your problem to disprove it."

Amber articulates at least two ways in which technology is seductive. For one thing, she enjoys knowing that the problem at hand *can* be solved if she thinks it through well. This is particularly satisfying in contrast to the situation she used to face teaching socially and economically disadvantaged preschoolers. There, the children often came to school reeling from the home crises of the night before. Amber had no control over those childrens conditions or the solution of their problems. The other thing that is seductive about technology is that it is intellectually challenging.

She comments that scientific knowledge and technology have a life of their own and *will* go on. We've been born into *this* time. And so, Amber reasons, "I better know how to relate to it; I better take some responsibility for trying to make sure that it's used in a way that I agree with." She reconciles the contradictions between the simple 'adequacy' of living in tents, and the complex 'responsibility' of getting up each day and going to work for 8 hours or more to develop more technology in terms of today's world and its conditions. She points to the fact that she lives on ten acres of land and takes walks in the woods to get perspective. Her technical job enables her to have ten acres to walk around in, in this day and age.

Dale Anthony

Dale Anthony is a very soft-spoken shy woman in her 40s. She loves animals and the outdoors. She describes herself as "pretty much a loner." She lives on a hill, on several acres, with woods, a picturesque pond, several swans, two large dogs, one (if not several) cat(s), and enough mowing to keep her busy two to four hours every weekend during spring and summer. She has named the place "Anthony's Woods" partly in honor of her father, whose name is Woodrow Anthony. She would love to some day add some sort of facility that would provide a home for wild animals that have been so badly injured that they could not survive on their own in the wild. Each year she makes it a practice to take at least one vacation trip, usually featuring scuba diving and/or ocean sailing.

She has taken several classes with Fight Back, an organization that teaches self defense classes to women. Her involvement there has recently inspired her to write poetry, something she did years ago but had set aside. She made at least two striking observations regarding the Fight Back classes she has attended. She said it is shocking when you realize so many women in the class with you don't know the simplest of things about defending themselves, things which boys and men *do* know. She also commented that a "fantastic bonding" takes place among the women in the class:

> It is shocking when you first go in there and all these women are standing around and you realize they're teaching you these simple basic things that any person on this planet should know but none of the women in the room know it, because women are not taught it. Males know it; females don't know it. . . . They teach you a set of scenarios and then later you get surprise attacks and you have to figure out what to do--which scenario, which pieces of which scenarios to do.

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And it's really good. And it's this fantastic emotional bonding with all the women.

Her feminist identity is a prominent part of Dale's self-image and history. She grew up in the South, an only child, and went to segregated schools through high school. In college (a public university in her home state), she majored in psychology, with an ambition to study medicine, particularly psychiatry. Her favorite classes, however, were "black power studies" in which she came to an understanding of what African Americans "have been through," and developed a strong respect for the people who had been referred to as "niggers" at home. She brought her feminist and anti-racist convictions home from college with her, leading to turmoil and an eventual transformation in her family.

When she wanted to work in the Head Start program during the summer after her sophomore year of college, her father forbade it:

> My father said that he would not allow me to work with 'those niggers,' and if I did that he would not continue to send me to college. So I did not get to work with Head Start. I also did not go home that summer. I worked in the chicken factory. . . . I loved and still do love my father a whole, whole lot—you know—and that pretty much broke my heart. . . . The end of the story is good, though. I fought with him for years over these issues. . . . They are so different than they were then. . . . I was successful. They don't use the 'n' word any more. . . . My father even a few years after that allowed me to bring in black friends—into his home—and did not yell and scream, did not say anything. . . . And my mother . . . later got into the women's movement, and through the women's movement she worked closely with black women. . . . They're totally different. They're in their eighties now.

During her senior year of college, she met Jill, who was involved in trying to start a "women's group" at their university. Those efforts were

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unsuccessful, Dale said, "But she and I became friends--and, um--and I became a radical feminist." After graduating, Dale and Jane moved to the state capital, where their parents lived. There, along with a third woman, they started what they believe was the first (feminist) women's group in their state. Dale gave her mother, among other feminist writings, a copy of *The Feminine Mystique*, by Betty Friedan. Her mother related to it strongly, and joined the feminist group. Dale, however, dropped out of the group after "a year or so" because she "was too radical for the group." "I can be too idealistic in expecting people and events to be too perfect," she commented. Her "mother stayed in it and became one of the leading feminists in the state." Dale's mother was involved in starting a shelter for battered women, did fundraising, went to marches, and later wrote a history of the battered women's shelter and a history of their women's organization. Her "father has become a feminist supporter."

Early Years and Educational Background

Her parents were in their mid- to late-30s when their only child Dale was born. Dale played with dolls a lot, and says she never had boyish kinds of toys. She supposes she fell into believing "to some extent" that science and mathematics were subjects girls were not supposed to like. Nevertheless, she was accustomed to getting good grades in school. When, in junior high, she saw that her standardized test scores in mathematics were not as far above average as her other test scores, she took more mathematics, which brought up her scores.

There were a lot of boys in her neighborhood, when Dale was growing up. While she "played dolls" by herself and with other girls, she enjoyed

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playing cowboys and Indians and soldiers with the boys. She didn't join in ball games with the boys, however. She doesn't remember ever participating in sports. She was in the band in junior high and high school. She doesn't remember the ratio of boys to girls exactly, but estimates the band usually had 25-50% girls.

Dale's parents both worked outside the home. Her mother, who had been a secretary before Dale was born, quit her job and spent the first seven or eight years of Dale's life at home with Dale before returning to her secretarial career. She was adamant that Dale would have a professional career and must have a good education. A secretarial career would not be good enough for Dale, in her mother's opinion. It was her mother's influence on the subject of education and career that Dale related to me in the interview, not her father's. Dale also recalls that despite her mother's insistence that Dale would have a professional career, she nevertheless made Dale take typing in high school. Dale had resented this, didn't try to do well in it, and regretted that it left no room in her schedule for physics, which she feels probably would have been beneficial to her in college.

In college, Dale pursued a major in psychology, with an ambition later to attend medical school and become a psychiatrist. She completed her B.A. in psychology, but her interest in medicine/psychiatry waned. Her rising social consciousness may have played a part in this. However, Dale mentioned 2 other important influences, which are described below.

Dale found in the first couple of years of college that she didn't like biology and chemistry. She didn't like the memorizing that was necessary in those classes. And she was uncomfortable with the required lab work. While she was confident in her ability to master the material in the book and in

lecture, the lab was an unfamiliar setting, and she was uncomfortable there; she felt "afraid" of failure with the lab assignments.

In her senior year, Dale took a course in experimental psychology that led her to a sense of "disillusionment with the whole science" of psychology. Her project for that term was to produce a research paper on the study of "perception of links of lines." The deeper she went into her investigation and the more researchers she read, the more contradictions she seemed to encounter. She was disturbed to find that one researcher might cite another researcher as finding a certain set of results, while she read that second researcher to be saying something other than--even opposite--what the first researcher cited. To her, such conflicting and contradictory reporting of science could only signal bad science. She wanted nothing to do with it. Her professor praised her for her critical review of the research, gave her an A on her term paper, and encouraged her to continue further study in graduate school. But she was asking herself, "How can I be a psychiatrist if there aren't really any clear answers or hope of curing people?"

When I asked if such conflict, contradiction, and disillusionment arises in her work in the field of computer science, she replied:

> I expect science to be good, accurate, truthful, honest. . . . There's probably some similar things, possibly in the way we work, producing products for people, but . . . I don't see it as the same. . . . I just view science as something separate. And to me, computer science is not science. We don't do experiments--research on it--where *it's* the focus. So I don't have such high standards for it as I do for science.

After graduating, Dale did social work, worked as an assistant psychologist in an institution for the mentally retarded, earned a masters in "human learning" (in a program that was "not accredited," she hastens to

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point out), moved to other states at least twice, and eventually settled into a nine-year career as a teacher of severely physically and/or emotionally handicapped children. Her background in psychology, particularly her interest in and respect for behavioral pyschology, served her during those years. She believes "there is a lot of good research in the field of behavioral psychology."

But Dale did not like her teaching career very well. She found it unpleasant to spend so much time with "violent and self-abusive" children, to need to always have a body guard in the classroom, and to be focused on "punishment" and on "programming" her words, facial expressions, and body movements in all her communications with the children. She came to see her job as one of "controlling people." She "ended up feeling like a monster."

She was about six credit hours shy of a masters in education when she became interested in computer science. After a year of studying computer science part time while teaching full time, she was willing to commit to a career change. She quit her job, sold her house, put herself on a strict budget, and earned a second bachelor's degree--in computer science. Upon completion of it, her uncle helped her find a job, across the country, in a southern state (other than the state in which she grew up), with her present company. She's been with this company over nine years now.

Dale believes many of the organizational skills she developed during her years of teaching severely handicapped children transferred to her computer science career. In her classroom, she had need to prepare, for each student:

-goals for the year,

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-plans to meet these goals,
-a daily schedule for each student for each subject, taking into account the classroom aides that would be working with her.

When she became a group leader (and was put on the fast track to a management position) in her fourth year with the company, she was the first to lay out a prospective schedule of the status of projects and the involvement of group members with those projects over a span of time. Later, project management software became available for this purpose. Her behaviorist training also transferred, she said. Writing microcode was as detailed and exacting as the behavioral approach to dealing with her students had been. Also, she was able to write a tutorial to teach in two weeks what had previously taken new programmers six months to learn about the microcoding project she was involved with. This tutorial was still being used when she transferred within the company two years ago, moving to a new state and taking a completely different job.

Current Job

The projects Dale is involved with at her current location are funded commercially. At her previous location with this company, the work was largely funded by defense contracts. As Dale put it:

> When peace broke out everywhere, that kind of shot that business down . . . and I didn't feel like my job was secure, so I looked for another job that I thought would be more secure . . .

She is glad she made the move. She has had to make adjustments, however. In some ways, she has effectively started over. At her previous location, she

was very successful. She "went all out" in her work there. She worked a lot of nights and weekends. She was a group leader and had been identified as promotable. She was on the fast track. In support of her ambition to rise into management, she embarked upon the pursuit of a masters in computer science. Her company began sending her, all expenses paid, to a series of summer sessions at a distant university. She is nearly half way through the program now. But she is disappointed that the coursework is more theoretical and less practical than she would like. She is seriously considering dropping out of the program.

Since her move to her present location, she has immersed herself in learning a completely different set of projects. Her momentum, and indeed her ambition, to join the ranks of management has diminished. She had qualms about giving up her management ambitions, not only because of the benefits to her in terms of status and pay, but she also "had qualms as a representative of my group: women--successful women." She knew the new location would be different from the old one, and so she allowed herself the time to see how things would go. It has taken about two years to decide she doesn't want to go back to management. This was a difficult decision--"not traumatic, but hard--to give up that goal." She now feels good about her decision. She is pleased to have time for herself and the other things that are important in her life.

There are things Dale likes about her work and things she doesn't like. The work is interesting. She enjoys learning new things. She enjoys the challenge of the projects. "It's like a game or a puzzle," she says. She likes trying to figure things out, getting things to work. She likes the feeling of doing a project well. And she finds the sense of completion when the work is

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finished "very rewarding." She has a "compulsion" about "getting things done."

She also likes the environment in which she works. "It's a good team environment." There are many people to ask help of, and she finds her colleagues generous with their time and knowledge if she needs it. She is past the period of having to prove herself on the job, but is still not at the level of expertise she had at her previous location, where her knowledge was constantly in demand. Thus she is able to work in uninterrupted blocks of time, which she likes.

She is pleased to be associated with as diverse a group of technical experts as she is surrounded by in her present location. (Diversity was not as strongly emphasized at her previous location. There was a less diverse staff there than is the case at her present location, even though both sites are with the same company.) Her present department consists of approximately 25% women. She estimates that the entire company probably has approximately 10% women. She finds her women colleagues hard-working, smart, and likeable. Not only are there women in greater numbers than in other parts of the company, but African Americans, Asians, Hispanics, and gays have a visible presence in her department. She is impressed with the young (mid-30's, she estimates) African American director who created her department, hired and promoted women and minorities, and has since been promoted and moved up the corporate ladder creating diversity all along the way:

> He promotes and hires women and minorities, you know, at a—you know—well, I guess you could say, at a *normal* rate, which is more than most people.

Still, she pointed out:

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Something I've noticed up here is that I look around and I think, 'Where are my older sisters in this workplace?' They're not here. . . . I can only think of one [woman colleague] that's older than me and she's the new department head, the Black female department head in my department. And all the other women, including the managers . . . in all the meetings usually I am the oldest. Sometimes I'm the oldest *person* . . . except for this one woman.

There are other things that could be better in the work environment. She wishes for better hardware resources and more control over the choice of development platform. But she especially dislikes the unrealistic schedules that often interfere with the quality of the work. She points out that the business climate nowadays dictates an approach to the work that all but precludes careful planning and thorough testing. To get the work, you have to promise to do what the customer wants, even when they aren't very clear themselves what they want. You have to promise to do it in less time and for less money than competitors promise. And you have to count on ironing out exceptions and other details later, after a business relationship has been established and commitment to and progress on the project are apparent. Otherwise, a competitor will get the work and you will have none. All too often, she finds herself "starting coding before having design specs." (This is a situation with which she is very uncomfortable since it leads to mistakes and often has to be re-written anyway.) What's more, design changes and additions often come in within only weeks of the agreed-upon project deadline, without any modification of the expected delivery date. Under circumstances like these, "they don't really give you the option of doing a really high quality job," Dale says. (However, code inspections, in which code

is reviewed in a fairly formal way, are helpful, particularly for the author of the code.)

Another thing that takes some getting used to is that there are "lots of different bosses. The negative side of it is no boss ever gets to know you real well, so you don't have much of an advocate. On the other hand, the positive side is that you have several bosses who know quite a bit about you. If you've made a good impression," that is, been associated with good work on projects, you've got multiple people speaking up for you at salary and performance review time. This has worked to Dale's advantage so far, though she has not scrambled to get in good with each new manager, since her goals have changed and she has gotten less interested in management.

As much as Dale likes her work, she appreciates setting it down and walking away from it at the end of the day. She finds she doesn't use her own home computer, doesn't care about computer games, is "more interested in animals, the outdoors, and relaxing." She doesn't want to "sit around home and read computer magazines and books; I'm just not that interested," she says. "I don't want it contaminating my home environment." She wants to keep her work interests "separate from home. . . . I have other things to live for." When I asked Dale if, in her work, she feels pride in being part of something important. She replied that it is "not that important."

Dale's advice to young women who are interested in pursuing a career similar to the one she has is, "'Do it!' I'd advise them to go into any field that is male-dominated and steer clear of any fields that are female-dominated. . . . If it's female-dominated, you can't make any money." As far as Dale is concerned there are no disadvantages to being in her field: "It's a good field."

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The money is good, the work is interesting and challenging, and "you get used to" having a lot more men than women around you.

Impact of Technology on the World

I asked Dale if she sees negative repercussions to the work she has involved herself in. "I think people worry too much about stuff like that," she told me. The environment is something Dale cares about very much, but she doesn't single out the computer industry as a primary culprit. She pointed to people's irresponsibility; the quest for money; not caring about other people, other animals, plants, the planet; the willingness to destroy *anything*. She hopes for some good political leadership to lead us beyond our crises. She cited a quote she had heard on a television program, "'No one should have two homes as long as some people have none.'" She struggles with her own sense of responsibility to the earth and those living on it:

> I think I first felt rich after I started working for [her present company]. . . . I keep thinking . . . that somehow some way I need to share. But I haven't figured out yet how to do it.

She has worked with Habitat for Humanity and would like to also volunteer with an organization that looks after injured wildlife, now that she has become somewhat settled in her new city.

We talked a bit about the possibility of technology dumbing us down with oversimplification. She sees this as:

> a real dilemma. . . . Sometimes the things that we try, to make it easier —with these buttons and stuff—sometimes it makes it more difficult because it limits your options; you have fewer options. But then on the other hand everybody doesn't know how to do all the detailed stuff and doesn't want to know how. So I don't know—I mean maybe what

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we need to do is provide multiple options, you know, allow the user the option to type in the commands themselves. . . . I think part of the problem might be, though, that for instance on the system that we're working on, the company that's going to own this--this software system--they want to limit certain users to only be able to do this kind of thing and that kind of thing . . . to prevent--you know--billing from being tampered with and somebody's home services from being tampered with. So there's always security, too. . .

Eileen

Eileen is a woman in her 30s who has risen to the level just below that of Vice President in her company. She is the Director of an entire technical Division of her company. Growing up, she "knew all along--just because of [her] up-bringing" (t17a) that she would go to college and "have some kind of a decent job. But there wasn't any big plan with that" (t17a) in terms of what she would study or what her career might eventually be. Both of her parents had college degrees. Her father had an accounting degree and worked as a CPA. Her mother had a degree in sociology and worked as an elementary teacher. Her grandmother, as well, had a college degree and was a school teacher. Eileen remembers, however, that her "dad was always the one who did our homework with us" (t30a). She describes herself during her elementary and high school years as "real serious, kind of quiet" (t30a). She liked to read and she liked math.

Eileen started college with "a scholarship right out of high school" (t17a). While she took a wide variety of courses that interested her, including mathematics, she began to develop a major in Fine Art. After 2 or 3 years, realizing that friends who were graduating with art degrees were working as waitresses, barely able to support themselves, she became interested in Computer Science, which "came easy" (t30a) to her. She graduated from college with a double major: Fine Art and Computer Science.

While studying computer science, she "liked the systems level--the assembly level--the machine language stuff" (t30a). She used her knowledge of operating systems and assembly language programming in her first computer job (approximately 2 years), and the expertise she developed there

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has also been relevant in her work with her present company (approximately 12 years).

Outside of work, Eileen has a wide variety of interests, spanning family, the arts, and fitness. Her 7 year old son is of primary concern to her now. Her husband's work frequently takes him out of town for days, sometimes weeks, at a time, so he is not always able to share the transportation and babysitting responsibilities for their son (though he shares all these things when he *is* in town. It is important to her to spend as much of her free time as possible with her son while he is young; otherwise, she comments, "Why bother [having kids]?" (t30a) She feels his parents should be there to do homework with him, to see to nutritious meals, and to just be physically present with him in his own home. Before he was born, however, she enjoyed playing volleyball and softball, riding bikes, walking, and jogging. She still jogs regularly, at lunch times and on weekends. She also used to paint and throw pottery, activities for which she is unable to find time nowadays. She continues to enjoy attending art exhibits, and going to the movies, though not as frequently as in the past. Her husband too enjoys these things. They occasionally meet while he is on the road to see special exhibits at art museums in distant cities. They are familiar with many of the local galleries. Eileen exudes energy and enthusiasm.

Her artistic interests are expressed in Eileen's job as well as in her private life. She hangs art prints in the computer lab that the associates in her division share. She even went to the trouble of applying for and obtaining official permission (approximately a month-long process) to hang some pieces from her personal collection in the hall outside her office after her most recent promotion, when she was given an office, 2 walls of which are all

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windows. She chuckles when she tells that story, imagining her co-workers saying, "Oh, god, there she goes" (t30b). She also enjoys entertaining and planning parties, and has been involved in planning the company Christmas party. But her interests in the art world are not shared by her fellow technical employees as enthusiastically as by her husband and friends outside the technical workplace. "I was thinking of renting out Nicholai or one of the galleries down there [in the 'artsy' area of town]. I'm thinking it'd be cool, you know, cocktail hour, sitting around [amidst the interesting and beautiful art]; and he's (the VP with whom she has been planning the company Christmas party) like, 'Now who's this for? Who in the world's going to appreciate this?' And he's right. . . . I do keep always trying to do things like that . . . It's just kind of funny" (t30b).

For nearly 10 years, Eileen was the only woman in the technical group in which she was hired and promoted twice, eventually becoming manager. Looking back, she feels "really proud" of the fact that by the time she left that group for her current position as director of the 81-person division of which the group is a part, "there were 6 or 7 [women] in that group out of 22 or 23. But the other groups . . . it's weak—probably 10 out of 80" (t17a).

Eileen estimates there are probably about 2500 company employees nationwide, and about 1500 to 2000 located at the home site, where she works. "When I got my last promotion I was just shocked at the women that sent me mail messages saying, you know, they just thought it was so cool. I had no idea that that was happening, that when I got promoted all these people thought it was great because they were glad to see a woman . . . . I never even realized people paid attention . . . . I'm glad that at least I can show other

people that they could do the same thing, that I can be a role model" (t30a). There are 5 women among the 30 to 35 members of the "executive staff" (directors and vice presidents) in her company. The others, and the company president as well, are men.

Although Eileen says she hasn't "run up against a lot of resistance" (t17a) as a woman working in her male dominated career and company, she acknowledges the atmosphere at work lacks diversity, race-, gender-, and other-wise: "No, *diverse* is definitely not what . . . the picture here looks like" (t17a). She comments further that "there's definitely more of Asian than some of the other" minority groups; and "the human resources department is targeting black colleges for candidates because we are really white male dominant" (t17a). A "Diversity Committee" has been formed, and she is on it, but it does not meet very often. Recent company crises have consumed the energies of company executives and managers.

In her own hiring practices, Eileen has tried to focus on finding the best person for the job. She points out that she sees far more men's resumes than women's: "The resumes that I—we received are mainly male. I didn't recruit the women that I got. It just happened that way. I just looked for . . . the best candidate" (t17a). She suspects that her experience of being able to hire a number of good technical women "has to do with the fact that [she's] a female manager" (t17a). She said, "I hired a few women and then . . . women see that women like a certain group and then they—we had a lot of internal transfers. . . . I mean a lot of women who interviewed with me internally said that, you know, they had heard . . . 'You were good to work with.' And they had come from bad situations" (t17a).

The group Eileen formerly managed has been split into 2 groups. She promoted 2 men into the manager positions of these groups. And they have each hired 1 woman since. "They have the same attitude [as I]," she says. "And I don't know if that was because that was my attitude but, I mean, nobody in that group thinks about, you know, sex or color or gender or anything. It's just, you know, 'Who looks like they'd fit?' Because we look at personality too" (t17a).

When Eileen was promoted to Director of her division, the "charter" she was given was to get *all* the groups in the division running as smoothly and effectively as the group (which has now been split into 2 groups) she had formerly managed. That group, and she, as its former manager, has "a very good reputation with higher management" (t17a). The larger division, however, has been somewhat plagued with "adversarial relationships" as well as certain software quality issues. "So my main emphasis . . . has been to work with the groups, . . . getting them to cooperate and interface with other groups. . . . I've been concentrating on . . . software engineering skills and communication" (t17a).

Eileen believes one of her most important achievements before being promoted to director was the establishment of useful software engineering procedures within her former group. She and another associate had become concerned with how to ensure they were producing and sending out relatively bug-free software. They split up the tasks of reading up on software engineering practices and technical reviews, discussed what they had learned, chose certain procedures that seemed relevant to their own programming environment, and began to put them into practice. What emerged was "a

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living *Documents and Procedures*" (t30a). Now, the programmers/analysts not only write software, but they attend to "requirements, [and] specs, and reviews of design specs, and walk-throughs of the code, and test plans, and test plan reviews" (t30a) in systematic ways and by means of peer reviews. "It's really not threatening. In fact, people [are] to the point now where they feel better--they feel more comfortable . . . with other people looking at their stuff" (t30a). Following these software engineering and quality assurance procedures had good results for the group. "Things are real structured . . . we had a really good reputation, we had high quality software, it went out smoothly, [we got] interesting projects. . . . You get to go to conferences, you get to, you know--you say you need something and people believe you. You know. Life is good" (t30a). This is what Eileen wants for the entire division; this is the "charter" (t17a) she's been given.

Eileen "like[s] working with people. . . . I think I've been successful at [my company] because I know the technical side of things . . . and I can work with technical people, but I also have some people skills, [and] I can . . . work with them on a personal level. I'm interested in treating people as individuals, and finding out what motivates each person and what each person needs, and finding the right job for what they like to do, and I *like* to do that" (t17a).

However, she adds, "It's a big challenge now, and I'd like to see what kind of progress I can make [toward] getting some of these people to work [or, as they say,] 'play' better with others. . . . They've always had kind of this "us versus them" [mentality], and I'm really trying to break that down and it's a real challenge" (t17a). Adding to the complexity of this challenge is a sort of "really agressive", "can-do", "make things happen", "fast moves", "well, get it

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done" pressure from above. "My boss has been saying lately that he values, you know, engineering procedures and . . . quality assurance in software. . . . But . . . then there's times when it's like, 'Well, get it done.' You know? . . . So we try and just always stick by our guns and say we can't, but we occasionally get overruled" (t30b).

[My job] is "a big part of who I am, what I am," Eileen says. Over the years, she has found great satisfaction in her accomplishments within her company, and in a sense of having made some worthwhile contributions. "But lately, you know, sometimes it gets harder and harder. Because, you know, it's cutting in so much into other things I want to do. . . . A lot of times I feel like, "Oh, god, [I] should take a break" (t30b).

While Eileen feels she has "never been treated differently" as a woman, she notes, "all the other women in my position, [that is,] the 2 other directors and the 2 vice presidents [who are women] do not have children" (t30a). She goes on to say, "All the men in these positions--I think some of their wives might work, but, [the men themselves] don't have to do 2 jobs. They don't have to do bed stuff. The problem is that I have to leave at 5:30. . . . I don't want to hire someone to pick up my kid every night and have me work till 8 and he goes to bed at 9. I mean, why bother? I mean I don't really have a child so I can see him [only] 1 hour a day. . . . Men don't seem to care. Um. But I'm not going to do that. So I have to walk out everyday at 5:30 because I have to [pick up my son] at 6 o'clock. . . . [Sometimes] I have to walk out of *meetings*" (t30a).

Eileen is quick to comment that this is not held against her. For instance, if her "boss" is in her office at 5:30, he'll remark that he understands

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she needs to leave. "Of course, it's to the point now where sometimes he walks me all the way to my car. I'm getting in my door, . . . and by that point I'm not really thinking about what he's saying" (t30a).

She also says that having to leave work as early as 5:30 is not a problem that is related to her being a woman. It's a problem because she is raising a child. And raising a child is a responsibility with which the others on the executive staff (mostly men) seem not to engage. "It's not because I'm a woman; it's because, you know, I'm a single mom most of the time. . . . I have to watch it because sometimes I get resentful. It's like, these people all have these wives [who] do their grocery shopping. They don't have to take off to take their kid to get his physical. They don't have to take their kid to the dentist. They don't have to, you know, be home at night because [the children have] homework to do" (t30a). And, with an ironic twist, she adds, "Like, I need a wife" (t30a), as if wives aren't necessarily women. Finally, she declares, "Sometimes I get irritated. Which I have no *right* to. That's my choice. But." (t30a).

Though Eileen leaves work by 5:30, the work of the executive staff seems without end. Occasionally, Saturday meetings are scheduled at work. Often, the vice president with whom she works most closely calls her at home in the evening and on weekends, and "He'll talk to me for an hour or so" (t30b). And often, this disrupts her activity with her son: "Classic example: my boss called me a couple of Sundays ago, and I had my purse on my shoulder, we were walking out the door to go to the discovery park. . . . I had to blow it off" (t30b).

But Eileen stands her ground and feels effective in her resistance to having work cut into her family time: "In fact, just last week there was a

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really major decision made, and they made it at 7 o'clock at night. And the next morning I was in my boss' office, and I was like, 'Why did you have to make it last night at 7 o'clock? Why couldn't it wait till this morning?' You know, I just don't get it. And he was like, 'Well, . . . I thought it was the thing to do and . . . I didn't think you'd disagree. . .' And I'm like, 'Well, you're right. Nothing would have happened differently. I just don't know why you had to make the decision last night at 7 o'clock. You know. Why couldn't it wait until 8 o'clock this morning?' And that's probably the first time that's happened. So it's nothing that—it's not an ongoing recurring problem. . . . I know he would never say . . . 'Well, like, you're never here late.' I mean, nothing like that would ever come up" (t30a).

Kate

Kate is in her 20s. She is shy by her own admission, but she is composed and articulate, and talks easily about herself and her work, in an interview. She is well-educated, having stopped just shy of the candidacy exams for her Ph.D. in Computer Science to take the job she has held for approximately a year. She comes from a family in which education was visible and valued. Her mother was a high school English teacher. Her father was a mechanical engineer. She fondly remembers "having a library card when I was three or something" and "doing the summer reading club at the library" with her brother (t15b). As a family, she remembers, they did a lot of "nature-related stuff . . . biology kind of science" (t15a).

Regarding her childhood interests and activities, and her preferences in toys, she says:

> Even when I was very small, I was always more interested in the building kind of toys: Lincoln logs and that kind of stuff. So I think that manifested at a very early age. I was not really into dolls. I was more into the traditionally male kind of toys. Building things. Digging in the dirt. Um—And that just never really changed (t15a).

Then, reflecting on her progression from an interest in "traditionally male" toys and childhood activities, to an interest in studying and pursuing a career in the technical, she adds:

> I remember deciding around 5th grade—I was looking through my dad's like college physics books—not understanding a word, but thinking, "This looks neat." And that was 5th grade. You know. That's pretty early. So I always—I started to like work harder in those kind of classes (t15a).

She also says:

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When I was very young--I mean if anything, people would have thought I would have gone into something more like literature or something because I learned how to read real easy but man I had troubles with the basic arithmetic. . . . But I really enjoyed the science stuff and--and it probably helped that my parents both went to college. . . . I think that was some influence, you know. Being exposed to that kind of stuff (t15a).

Her "trouble with math" ceased when she "hit algebra" (t15a). And she continued to "work hard" on her science studies through middle and high school.

By that point it was pretty much everyone's assumption that I would go into science. And I never really questioned that--I mean, you know. I don't think it's *bad* that people had that assumption. Though I really seriously never did give a thought to doing anything else, and sometimes I wonder if I should have. Because there *is* a part of me that isn't totally a science geek. . . . So it's sort of like opposite. I think a lot of women don't even think about going into science because, " Well, of course. I wouldn't even think about that." I was sort of the opposite. By that point everyone had so much assumed that I was going to go into science, it's like if I had suddenly decided to become a literature major, people would say, "Huh? Why?" So . . . (t15a).

Kate majored in engineering physics as an undergrad, where computer science was her chosen technical elective. She was good at computer science, but she felt less confident with her physics studies.

It came a lot easier to me than the physics did. . . . That's why I went into computer science in grad school instead of physics. Because in physics I found I was capable of passing the classes, but man, it was a lot of work, and I never really felt totally confident about it inside. You know, I always have this trouble because . . . I've been told by many different people many different times that I under-estimate my potential. But sometimes I honestly don't agree with them and I think that I'm just bailing before I get into deep water. So that's why I decided to say, "Enough with physics." You know. It was interesting, but to go on with computer science (t15b).

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During grad school, her favorite responsibilities as a paid graduate associate were her teaching responsibilities, though she also enjoyed her work in Unix system administration. Now, in her job, she enjoys "work[ing] directly with the people that are going to be using what I produce or what I answer" (t15a). In both positions (the teaching position and her present position), she has found "feedback," and thus her own gratification, to be "immediate" and "direct" (t15a): "[The feedback] is a way to know that you're doing something that's at least in some way worthwhile" (t15a).

Kate finds that while she is good at her work, likes her work, and needs to have a certain amount of freedom in doing her work, she also appreciates having the "direction" that her manager provides (t15a). She told me, "I've always been one of those people that—I've always been able to be successful at things like school because I was able to force myself to work hard. But it's always a challenge to . . . get the gumption or whatever to do the work" (t15a). She also said,

> I tend to get lazy about projects. . . . My office mate [was] on this one project where he was working like 12 hours a day for 3 weeks solid to get this one thing done. And I just never do that because I just don't think this stuff is all that important—in the grand scheme of things— you know. . . . I mean, I worked really hard the week before I went to this conference. Actually, just last week I was at a conference. It was the first conference I actually presented a paper at. And I worked really hard because I was really nervous. Um, but, yeah, I—I'm interested to a certain degree but after a certain point I lose interest. Which perhaps, I have hypothesized, is one reason I don't at the current moment have a Ph.D. Because I was never able to get *that* intense about anything in grad school (t15b).

"Gumption" also came up when we discussed her long-term career interests:

> I'm not one of these people that joins the company and then immediately starts climbing the corporate ladder—and somehow I think this discussion came up at work once. And I think what I decided on then is about the only level of management that I can

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currently imagine enjoying is one level up. Like--uh--the team lead or--uh--something like that. And even that--not right now. Um. Though I could imagine sometime. Um. Because actually about long long term, I'm not even--I still don't really know what I want to do long long term because I certainly have an interest in all this stuff but it's one of those fields that change so quickly you really have to keep on top of things and I . . . never know how much gumption I'm going to have to do it. And so--you know--I hate to just go into management just to get out of the technical, or just because I think I've fallen behind in the technical. . . . I guess the reason that it appeals is because . . . you can direct more *where* things will go. Um. And say, "Now, hey. We need to put some more people on this. This is a neat project."

But . . . I also like remaining in some sense unentangled. . . . I sort of like the freedom of knowing that--well, actually, at the moment I couldn't quit without feeling guilty because I *am* in the middle of a few projects but within 6 months I could totally unentangle myself from everything at work and not feel guilty at all about quitting and I sort of like that. And in the large part that's just because I just don't take any of this stuff all too seriously. And I--I think that's one of the main reasons I wouldn't want to get too much into upper management is because you have so many tangled allegiances. . . . Also I really am a rather shy person even though it doesn't seem like it sometimes. . . . I don't think I'd feel very comfortable in the upper-management because its very competitive and you have to really be outgoing and hand-shaking, I think, . . . to get a lot done (t16a).

Kate estimates that there are between 2000 and 5000 scientists, engineers, and support people on site where she works (t16b). Many of these people are employed by contract firms, as is Kate. In her division, the Computer Services Division, there are approximately 200 to 250 people, mostly contractors, all housed in a single two-story building (t15a). These people have been organized into approximately 10 to 15 sections.

"And of the maybe--I'm just guessing--10 to 15 people who are fulltime managers, there's--um--I can only think of one--one woman right now. Possibly there may be 2. But not more than that. . . . All my direct managers are men" (t15a).

Everyone in her immediate workgroup is a man and "pretty much, it's all been men" (t15a) with whom she has worked on projects in collaboration with scientists and engineers from divisions other than Computer Services. She has one responsibility that involves her with other women:

> That's the group of system administrators that I'm sort of affiliated with—there are some women on that. In fact the team leader on that [is a woman]. . . . The size of the team has varied. It hovers around 6 to 8. And they're up to maybe 3 or 4 [women]—so it's actually been [as much as half women]. I'm sure it's a much higher rate of women to men than are in like the OSU undergraduate or graduate [computer science] program. Uh, but that's pretty much the only women that I really associate with [on the job] (t15a).

She feels like, as a woman, she has been treated well in the year she has been with this organization:

> Yeah. I haven't had any real problems. Er—I haven't had any problems at all. I don't know. I think people are very appreciative. And I think it's —um—a pretty good environment. Uh. Government—I mean historically—apparently has not always been friendly to like women and minority groups. But even though people grumble about all the little . . . appreciating diversity kinds of programs, I think they *have* made a difference. . . .

> And actually . . . to some degree I can see why some people think they've gone overboard with this because it's like the civil servants, the real government employees, are like—they're always being required to go to some kind of sensitivity training or other. And in a way I think . . . you can carry it too far because it has created maybe—I haven't felt it personally but you can feel a small backlash. Like you know a lot of the white male engineers—you know—do have a point that . . . there's so few new jobs as civil servants and they're like, "Well, you don't have a chance to get that job unless you're a minority." A little bit of backlash like. You know. They're basically, "If you don't meet the right ethnic diversity you don't get the job." So . . . they feel it's almost like the opposite of the kind of discrimination it used to be. Like it used to be you *had* to be white male. . . . I don't really know enough to know if they have a point there.

But as a result of all that stuff there are a lot--well, compared to engineering in general, there *is* a lot more women there--um though-- as a guess--in Computer Services--maybe at *most* a third women, probably more like a fourth or fewer--just a guess (t15a).

Kate is glad to be doing civilian rather than defense research because she doesn't have a "dilemma" around wondering how her work is "going to be used--whether you're going to approve of how it's used" (t16b).

Tamra

Tamra is a woman in her 20s who decided on a computer science career in her early teen years. She attended a state university in her home state and pursued a major in computer science without any second thoughts.

Until 9th grade or so, Tamra had been interested in the field of education. Her father, whom she greatly admired, was a teacher, and her brother, 12 years older than she, majored in education in college. When her brother finished college, he was unable to find a job in education, and eventually settled into a career selling insurance, with which he is not happy.

Tamra's mother persuaded Tamra to consider her father's and brother's respective struggles with the field of education in her choice of career. She pointed out that Tamra could

> make a little bit more money [in a computer related field than in teaching]. She [said], 'Computers [are] the way to go.' And fortunately, it interested me. It had something to do with mathematics and science, which was really up my alley. . . . I started taking computer classes in high school. . . . I thought, 'Well, I like this, and it's got good job potentials when you graduate.' So I just went for it. . . . [It] never entered my mind to even change majors. [I] just thought, 'This is the way it's gonna be.' . . . It just so happened that I liked it, which was nice (t7a).

Education

Tamra must have been an energetic, enthusiastic, and creative child. She took music lessons for six years, learning to play the accordian and the piano. One of her favorite projects was taking her bike apart, painting it, and 'suping' it up. In the 8th grade, she became involved with organized sports,

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and she remains active in competetive sports and other athletic activities. She is especially fond of softball and bicycle riding.

Tamra did well in school in all the subjects. She knew as early as "first or second grade" (t7a) that she was good at mathmatics and science, the subjects that led her to the field of computer science.

> In elementary school, those were always my favorite classes. My dad was a math and science teacher, also. We always watched NOVA. . . . I always liked documentaries on science and things like that when I was growing up (t7a).

Later, Tamra found she liked the 'hands-on' classes she took in school. In junior high school, she had at least 3 different semester-long courses covering metals, industrial drawing, printing, silkscreening, woods, and foods (home ec). She found these courses interesting and fun. So was also enthusiastic about the labs associated with her high school chemistry and physics classes. About these, she said she

> loved it. I really credit a lot of that to my teacher that I had in high school. He was super, . . . very animated. Really made learning fun. And so the labs were fun too (t7a).

In high school, Tamra took 4 years of mathematics, 2 semester-classes in computer science, biology, chemistry, and physics. She very much enjoyed and did well in all these classes. She estimates that "fewer than half" of the students in these classes, especially the most advanced of them, were girls.

> But of the girls that were taking those classes, I think me and maybe 1 or 2 others were genuinely interested in it. They were just taking it because they were taking all the honors classes and it was just kind of a requirement and they were just doing it to get through it (t7a).

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All these classes were taught by men, except for one mathematics class. And the one woman mathematics teacher was replaced by a man when, halfway through the year, she went on maternity leave.

The math-and-science way of thinking about the world seems to have always been natural for Tamra. She acknowledges, however, that she had enormous support from her family, had good science-and-math role models in her family. She comments that she was not exploring "new ground" in choosing to study, and in doing well in, mathematics and science; nor was she "the black sheep of the family. Definitely not" (t7a).

The job

Yet her job is something of a disappointment to her. Low self-esteem and short attention span are 2 faults she finds with herself when she discusses what is lacking in her job. Throughout her formal study of science, mathematics, and computer science, she was an outstanding student. She went to college on an academic/athletic scholarship and is a member of the Phi Beta Kappa honor society. She was chosen to be a summer intern with her company during the last 2 summers of her years in college. Upon graduation, she was offered a fulltime position with her company.

Her job responsibilities include carrying a beeper and being on-call 24 hours a day. Her maintenance of the computer databases and systems for which she is responsible depends upon her intricate facility with hardware issues and assembly language code:

> With assembler, if I'm debugging assembler code—you know—I'm very confident of that. I feel like I'm in the driver's seat. I know what's going on. Um. I know where to look for certain things. It's kind of

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just a familiarity thing. It's like you've been with someone for 10 years--instinctively you know what they're doing without actually seeing it, if you know what I mean (t6a).

Self-esteem

She is uneasy about the upcoming migration of the systems she works on to a different computer platform, to different computer technology. She finds it kind of "scary" that all the expertise she has developed over 7 years or so with the company will become obsolete, and she will be expected to perform her present duties using unfamiliar tools, in addition to keeping up her current skills during the transition time, maintaining a hectic pace of turn-around on bug detection and fixes, absorbing whatever new training she may receive, and pitching in to do other people's (somewhat unfamiliar) work while they too receive training.

> It's hairy. . . . I guess I'm kind of looking forward to learning something new . . . and maybe getting up to speed with everybody else [who already knows the new systems] . . . but like I said, I think I have this self-confidence problem where I'm really scared . . . about it. I'm afraid I'm going to fall back . . . because right now I'm really doing very well. . . . I'm thought of well. . . . I'm doing good at my job, and now that everything is shifting to this different platform, I'm like, 'My god, what if I don't pick this up and . . . really fall behind?' . . . it's scary (t6a).

She acknowledges that her uneasiness about possible failure is probably not realistic:

> I very rarely get negative feedback. . . . I've never really had anyone sit down and say, 'Wow. You're doing this wrong and you're doing that wrong.' They never say that. So I guess maybe I compare myself to people who excel in certain things (t7b).

In fact, she also comments:

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I feel like I'm always trying to please someone, and if there's nobody there to please, then I don't take [failures and shortcomings] as hard as if there is someone there to please" (t7b).

Attention span

She feels like she's "really being bombarded. . . . I mean I feel like I'm on a roller coaster and have no control over what's going to happen and a lot of times it's just pure luck that I can find problems [under the new platform]" (t6a). "But everytime I think about it, I can't think of anything I'd rather do at [her company] than [her present work]" (t6a), Tamra says. One thing she likes about being on-call 24 hours a day is that if she comes in for a couple of hours during the night to solve a problem--and this happens about once every month or month and a half--she can then shorten some other regular work day, and have some time for herself. (She sometimes likes to take a few hours in the middle of the day to ride her bike or jog.) She also prefers the immediacy of her maintenance programming work to long term development work:

> I've probably got the attention span of a 3 year old. . . . It's really tough for me to sit down and be given . . . a 500 hour project [and be told], 'Here. You are going to be working on this for the next 2 1/2 months. . . . Have it done by March,' or whatever. It's really hard to sit down and dedicate yourself 8 hours a day, 40 hours a week, to working on something that the deadline's not for another 3 months (t6a).

She talks more about her "short attention span," commenting that, in comparison, she seems to have a greater diversity of interests in her life than many of the people she is around all day at work:

> Maybe it's because I like doing so many different things that I have this--what I consider a--short attention span--which is kind of a bad

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word for it--where I just want to be going from one thing to doing another, to doing another, which--they're all different, you know what I mean? . . . The majority of the people that work over there are pinheads, you know? They're strictly math, science, and 'just get away from me if you're going to talk anything else,' you know. . . . They're into their computers (t7a).

She "definitely" prefers situations in which she is "working with people" to ones in which she must work in isolation (t6a). However, she says, "Sometimes I find . . . I'm not the type of person who will just immediately run up and go ask somebody a question. I usually want to really mull it over good. . . . I really try to cover all my bases before I go and ask a question" (t6a).

Male-dominated workplace

Tamra's is a male-dominated workplace, any way you look at it. She is the only woman in her immediate workgroup of five programmers. With approximately 6 years experience with the company, she has less status and lower pay than the men in her group, all of whom have been with the company more than twice as long as she. She enjoys working with them, however, and finds sports to be a point of common interest and banter. "I can talk sports with the guys, and it's almost like I'm accepted as one of the boys, if you know what I mean."

The male presence of Tamra's day-to-day experience extends beyond her work group.

My immediate manager is a man and above him is a man and then it's men all the way from there on up. . . . Our department has, I'd say--of all the non-management workers--probably a hundred, maybe a little over a hundred. And there are . . .4 or 5 managers. . . . Each manager has about anywhere from 15 to 20 people working under them. Two of those are women. . . . There's no other women in higher management

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positions than that. . . . That's just one of the departments in [our division of the company]. There's 2 other departments. . . . I think there are just 3 other women managers in those other 2 departments combined. There's not a whole lot as far as women management goes there (t6a).

Tamra does not feel that, as a woman, she is treated differently than men at work.

> But I know that other women do feel that they are treated differently. . . . And I don't know if any of that's related to maybe their [feeling] slighted as far as their salary goes, or if it's just . . . the way that they're dealt with on a personal level (t6a).

Tamra also believes she gets the interesting projects as often as men do at work. She attributes this, however, to a certain desperation on the company's part to get anyone at all to do the kind of work she does. She is, afterall, on call 24 hours a day.

Tamra suspects she may be different than the men around her in certain ways, however. For one thing, math, science, and computers are not her only interests:

> I don't get any computer literature at home. Once I'm out of there, I don't want to really deal with it very much. I don't get into reading magazines or I'm not in any computer clubs. I don't have a PC at home. . . . I've got other things I want to be doing outside of work (t7a).

For another thing, she finds involvement with people to be an important component of work satisfaction:

> I have a lot more fun working with people (t6a).

> . . . working with people and helping people. I think that's just part of my personality. I feel like I have to help people and I don't know if that's part of being a woman . . . I've noticed that women feel they

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have to be there for everyone every moment, every minute of the time, and they don't take any time for themselves and I'm the exact same way. I feel if someone has a problem, it's my responsibility to help them (t7a).

In addition to (1) having broader interests than many of the men at work, and (2) wanting more personal involvement on the job than she gets, Tamra suspects that, in part, her fragile self-esteem represents a difference between women and men where she works:

> I think women tend to judge themselves a lot more harshly than what men do because I feel women have this thought that . . . they have to be everything to everybody. You continually be there for people (t7b).

In general, Tamra sometimes feels like she doesn't fit as well as she would like or as well as she had thought she would when she was a computer science student. "It's almost like you're a failure," she says of the feeling.

Massage

Tamra is currently enrolled in school in a program in massage therapy. She takes classes, studies, and works in the clinic evenings and during her time away from her technical job. She expects to become state certified as a massage therapist by 1996. After that, she will be able to work and earn income in the field of massage therapy. This situation introduces conflict for Tamra. She likes her massage work. She likes working with people. She likes the interaction and the feedback she gets in clinic. She likes feeling that she has helped someone feel better:

> When these people come in for massages, . . . they feel terrible. I give them an hour long body massage, and they walk out floating . . . and . . .

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they're . . . feeling great. And I'm thinking, 'Boy, this is such a nice feeling to be able to help people.' And I think part of me wants to take that path next (t7a).

The conflict for Tamra has to do with the fact that she likes her technical career at least as much as she likes her massage work. Her above statement continues:

But then I've got this logical side of me that needs to have some kind of fulfillment, which is why I was hoping maybe there's a way I could work out working part time at [her current company] and part time doing massage work, and that way I can fulfill both of these needs. . . . It's a really bizarre feeling. Because with my job now I'm solving problems and I really like doing that. I love debugging. And with massage, you're kind of doing the same thing. People come in with problems. They give you the symptoms. You try to figure out where you have to spend most of your work on their body to help relieve whatever tension, whatever knots they have and that's . . . a . . . correlation between the 2 jobs. . . . But with that you get to work with people and make them happy. Over here, I'm working with problems and nobody's happy. . . . When you get them solved, it's like, 'Okay. You did your job. That's what you're supposed to do.' It's not, 'Oh, thank you, thank you, thank you.' You don't get much appreciation (t7a).

And just as Tamra sees problem solving, or "debugging," in her massage practice, she also sees "mathematical, analytical thinking" (t7a) in her study of massage. This seems particularly apparent in the required anatomy and physiology classes, where she and another computer scientist in the classes "apply logical thinking sense" (t7a) to the learning of the material. Students whose clinic work is top-notch, but who may not have gone to college, or who may think differently than Tamra refer to her and the other computer scientist as "Einsteins" (t7a). Tamra thinks the logical, analytical, mathematical style of approaching the most technical aspects of learning

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massage therapy is not merely useful, but also important. She hopes to eventually get into something "more clinical" (t7a) than full body massages. She would like to:

> work with athletes, get down to pin-point massages, solve people's ailments. . . . [I] want to know, well, when I'm doing this, what is really happening? . . . What am I really doing when I do this certain procedure (t7a)?

A Better work setting

Tamra would love to be able to work half time in computer science and half time in massage therapy. She doubts her company would go for that, however, so, at least until she can see a financially viable way to maintain access to both careers, she will stay where she is. If she could re-make her technical job according to her fantasies, her workday there would be considerably shorter. She would also like to have projects where she works closely with others to produce a useful result. She would also give consideration to the care and comfort of the body:

> I would have a job where I could do my hands-on programming, also work with people, somehow. I don't know how that could be accomplished. But if we could work on a project as a group perhaps, some type of group project, where you have a lot of interaction with people and this may sound really crazy but if you had a workout facility there where I could go down during lunch, or just anytime during the day and burn off some steam, I mean that would be fabulous. I'll leave at 3:30 sometimes and just go for a run or just do something, just anything, just to get out of there, and then come back. And this is another crazy thing. If I'm wearing comfortable clothing, I can work a lot longer than I can if I'm confined to a suit and pantyhose (t7b).

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Epilogue

The presentation of these profiles is intended to impart something of the variety of women in the study and something of the kinds of things they talked to me about. These particular five women came from four of the six companies from which I interviewed women for this study. Their ages ranged from 20s to 40s. They were reflective and articulate. As with all of the women I interviewed, I found them very likable, even though I didn't always relate to their interests.

Three of the women profiled have had changes in their careers since I spoke with them. Kate has moved to a different state and taken a different computer science job, after three years with her first company. After becoming licensed in massage therapy, Tamra quit her computer science job, and has opened a clinic providing massage therapy for athletes and general clients. She writes, "It's great to go to work at a job you like!" Eileen has been promoted to vice-president of her company!

Dale has had a change too. Recently, she took a 7-week leave of absence from work in order to adopt an abandoned baby girl from another country. In just a month she was able to nurture her young daughter through several months worth of remedial developmental work. She is now back at work feeling a renewed sense of purpose in both her work and her private life.

CHAPTER 5

CONTRADICTORY EXPERIENCE, MULTIPLE SELVES

> "Identities seem contradictory, partial, and strategic."
> --Haraway, 1991, p. 155

Early on in my research process, it struck me that in my study of women computer scientists in scientific and engineering environments there would emerge no simple profile or pattern. The literature seemed to be all over the place on women's experience of science and technology throughout history. In my earliest interviews women described an experience that was not altogether like my own. Their respective experience differed from each other also. I came to realize that there are many stories to be told about how women experience technological professions. As Autumn Stanley (1983) and Margaret Alic (1986), among many others, have demonstrated, women have always been involved in the development and use of technology. On the other hand, it is clear that women have never been fully involved in the development and use of technology (Hacker, 1983, 1989; Wajcman, 1991). Mathematics education/achievement has served a gatekeeping function in the systematic exclusion of women (and other marginalized groups) from technological endeavor (Sells, 1973, 1992; Hacker, 1983, 1989; Cohen, 1982). Studies consistently reveal that women who do enter into technological professions are paid less than their male colleagues and are less likely to have

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powerful leadership roles (NSF, 1996; NAS, 1994; Hemanway, 1995; Isaacs, 1995). In fact, science and technology have been defined as male, leaving women no place from which to engage with/in science and technology without calling into question their very identities as women (Keller, 1985). These are just some of the stories that can be told about women's experience of science and technology. Each of the twenty women in my study has a story of her own. Each of their stories intersects with each of the stories I have sketched in the review of the literature.

Having made my peace with the fact that there is no global "women's experience" of involvement in the development and use of science and technology (computer science in science and engineering environments, in the case of my study), I nevertheless remained overwhelmed by all the intersections and disjunctions. What meaningful stories might there be across the experience of the women computer scientists in science and engineering who participated in my study? There seemed to be contradictions of every sort throughout my data. The women seemed to contradict themselves *within* their interviews. And *across* interviews, women's statements seemed inconsistent and contradictory. Once again I found myself in a confrontation with the paradox of multiple truths. In this chapter, I explore some of the contradictions/multiplicities that emerged for me. The stories of this chapter are stories of irony and paradox. I have loosely grouped examples from the data into three different discussions here. The first discussion is concerned with the notion that the women in my study are both insiders and outsiders with respect to their technological professions. There are ways in which they are fully and equally members of their professions, and yet somehow they are not quite fully participating members

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of their professions. The second discussion focuses on the extent to which the women involve themselves in extra-professional activities that are interestingly non-technical. They seem to shed their professions and pursue outside interests that take them far afield from the engineering and computer science of their daily paid experience. The third discussion is an examination of "diversity" contradictions. While these white women work among many other women and men, African Americans and Asians, people from diverse cultures and regions both within the United States and throughout the world, and people with various academic majors, there exists an unrecognized/unacknowledged lack of diversity in terms of educational opportunity and socio-economic background.

Both Insiders and Outsiders

The "contradictory, partial, and strategic" (Haraway, 1991, p.155) identities of the women computer scientists I've spoken with are reflected in many ways in many of the things they say. At one moment a woman might tell me she has always been treated fairly and as an equal to her male colleagues. At another, she might characterize her professional position in terms of the differences between herself and the men. The women's loyal, almost fierce, insistence that they are full members of and participants in their technical professions seems belied/betrayed by the other things they reveal about their experience.

It seems to me that making it in this world takes, on the part of the women, a certain amount of steadfast refusal to believe in the existence of forces of exclusion in the engineering and scientific workplace. The culture of the engineering and scientific workplace demands a reverence for and

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adherence to the notion of "objectivity." Equal treatment is supposedly dispensed on the basis of equal ability and skill. The notion of merit as a basis for membership and recognition is integral to this system. In the face of these notions, however, problems arise for women and other marginalized groups. They might wish to ask, for instance, "Who decides, and how is it decided, what is meritorious and what the objective standard is?" Perhaps the allegiance to a notion of objectivity, which is the cornerstone of science, engineering, and technology, confounds the experience of women in the technical work environment, and the understanding of that experience.

Never Treated Differently

Certainly, the women *are* working in the field of computer science, applying their expertise to issues of science and engineering. Certainly, they *have* demonstrated the intelligence and the "gumption," to use Kate's word (t15a, t16a), to earn admission to this exclusive, male-defined, male-dominated realm. They are abundantly clear on their membership in their chosen profession. They unmistakably resist any suggestion that this membership may be in question. They identify with the image of technological competence associated with members of their profession, and they take pride in this identity. They report that they feel they "have never been treated differently" (Eileen, t17a) than their male colleagues at work. Or as Chris said, "I've always been pretty much treated with respect and I've never thought that anybody didn't take me seriously (Chris, t13b). Often, they report that they fit right in as "one of the boys" (Tamra, t6a), and "don't stand out" (Eileen, t30b) in ways that anyone might fault them for. At the very least, they feel they are "not being oppressed terribly by anyone" (Amber, t24a)

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in the workplace. Indeed, their very identities are tied up in their professions. As Eileen put it, "[My] job is a big part of who I am, what I am" (Eileen, t30b).

Can't be Heard

On the other hand, their insider status, in subtle ways, seems to be limited. In meetings or informal technical discussions, the women sometimes have found they "couldn't be heard" (Amber, t24b). Their ideas sometimes get overlooked, underestimated, or belittled. Male colleagues sometimes take their ideas and run with them, earning credit and recognition in the process. Many of the women commented on this phenomenon, saying they had resolved just to be happy that their ideas were being implemented, and the project, group, and/or company would benefit in the end (Marie, t5, t8, t9; Amber, t24b; Eileen, t17a, t30). And yet another comment on this phenomenon was that silence often *is* an important contribution, especially when individuals' egos obscure the goals of the project, the group, or the company (Amber, t24a).

Family Responsibilities

Women are outsiders with respect to the male-defined, male-dominated technical workplace in a way that, for some, may seem more tangible than the experience of being unheard or invisible. They carry family responsibilities. To them, it seems they subscribe to an ethic of caring that they don't see manifested in the men they work with. If the women are married, they have the well-known responsibilities of taking care of the household. If they have children, they have the further responsibilities of attending to the welfare of the children. Even without husband or children,

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they often look after older relatives such as parents, aunts, uncles, and in-laws. They often maintain family relationships and involvements outside the immediate sphere of the traditional nuclear family. Eileen talked at some length about the difficulty of juggling her work responsibilities with her family responsibilities. She has tales of leaving late-afternoon meetings early in order not to be late picking her son up from after-school care before its 6pm closing time. She has tales of being walked to her car by other company directors and vice-presidents who continue to discuss company business, even as she is trying to change her mental mode from business to family. She says:

> I have to watch it because sometimes I get resentful. It's like, these people all have these wives [who] do their grocery shopping. They don't have to take off to take their kid to get his physical. They don't have to take their kid to the dentist. They don't have to, you know, be home at night because they've got homework to do (Eileen, t30a).

And, with an ironic twist, she adds, "Like, I need a wife" (t30a), as if wives aren't necessarily women, in whose own lives these issues arise as if in recursive relationship to Eileen's problem! Finally, she declares, "Sometimes I get irritated. Which I have no *right* to. That's my choice. But--" (t30a). To some extent, she sees her dedication to her family as undermining her success in her career, since she excludes herself from important conversations if they occur outside of regular business hours and at times which conflict with her family responsibilities.

Collaborative Style

The women also feel less than fully included in their professions--or at least see themselves as not quite measuring up--with respect to the working

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style of their most influential and successful male peers. Amy, for instance, transferred for awhile to a group whose male supervisor seemed to value a variety of working styles, including the collaborative style that Amy feels she tends toward. For her, there is isolation in working among people who prefer to work alone, and she finds most of the men she knows at work prefer working alone, behind a closed door, rather than in collaboration. When they do come together in meetings, Amy feels they sometimes are unnecessarily contentious and confrontational. Amy's new group was more than half women, and the work was somewhat less technical than she had done before. She liked this experience, but eventually went back into a highly technical group rather than risk losing her technical edge, and thus her value and promotability within the company and her ability to find well-paid work elsewhere in her profession.

Chris, too, talked about the benefits of a collaborative approach to her technical work. She feels especially comfortable about the design and code reviews that are standard practice in her present work group, but were not done in her previous group. "Personally, I love people looking at what I did because it gives me a little more sense of comfort. So in the place I'm at now we have code reviews. We have design reviews. And so I feel much better. And if something is wrong at least I know somebody looked at it. . . . It's important, I think--the process" (Chris, t13b).

Maintaining Technical Competence

The women often expressed a sense that they might not be keeping up technically as well as they should, that they might be sliding behind on knowledge and mastery of current technological trends, advances, issues and

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methods. They expressed concern about their ability to stay competitive: "I still don't really know what I want to do long-long term because I certainly have an interest in all this stuff but it's one of those fields that change so quickly you really have to keep on top of things and I--don't--it's a constant thing--I never know how much gumption I'm going to have to do it" (Kate, 16a). A number of the women say that being able to "talk sports" (Tamra, t6a; Eileen, t30b) is an important or at least helpful way of gaining and maintaining a sort of insider status, an informal connection with the male network by which news of technical innovations, new tricks, and new directions makes the rounds.

The irony about the women's uneasiness about having and maintaining technical competence is that they have already proven themselves capable and competent technical learners. For these women, the study of science and/or mathematics was always compelling, interesting, exciting. They *have* successfully negotiated the "critical filters" (Lucy Sells, 1973) that mathematics and science education have provided. It was their success in these studies that lead them to choose to study computer science and to work in science and engineering environments. Usually, they had better than average grades in their technical coursework among male peers in college. And they say that one of the things they like best about the technical work in which they are engaged is that it is "interesting" and "challenging" (Dale, t22a; Chris, t13b; Eileen, t17a; Kate, t15a; Jane, t19a).

Money

If the women in this study are both insiders and outsiders with respect to their sense of being able to maintain technical competence in their

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professions, their financial compensation also makes them both insiders and outsiders. Besides intellectual stimulation, the women say they like their technical professions for the money they can earn doing technical work. In fact, money was mentioned by all the women as their most important reason for pursuing and sticking with their technical careers. It has given them access: access to the financial means to support themselves as they wish, access to a certain status, a certain social standing, a certain power, that they don't think they would be able to enjoy otherwise. Cecilia commented that a technical profession provides access to "decent money" (Cecilia, t31b). Chris remembers that her dad worked three jobs: "Seeing how hard my dad worked, I [thought], 'I really need to get a good job.' That was a lot of motivation for me" (Chris, t20a). Amber said she had been concerned about how she could support herself and her son on her teaching salary before she got into computer science. Dale commented that the only way to make money is to be in a male-dominated profession such as her technological one (t17b, t22a). Ironically, however, research reveals that women in technical professions are only paid about 70% as much as their male counterparts (NSF, 1990).

Few Women

Women computer scientists in scientific and engineering settings have something of an outsider status by virtue of there being so much smaller a percentage of women in their work environments than in the population in general. The women in this study are usually in groups that have no women in the chain of command above them. Eileen has thrived in spite of being the only woman in her group for ten years. She has worked well with and for

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the men around her. She was promoted; she brought other women into her group; and she was promoted again, and asked to do with the larger division what she had done in her development group, to get people to work well together in an efficient, effective, and congenial way, to produce software whose quality could be assured. Michelle and Cecilia, too, were the only women when they were hired into their respective settings, and again when they were promoted (Michelle, t26a, t26b; Cecilia, t31b). Dale pointed out that the women who *are* there are mostly younger. All the women have experienced (or still do) some degree of isolation from other women co-workers and supervisors.

Non-Technical Outside Interests

> **After working with computers all day at work, I**
> **have absolutely no desire to use one at home.**
> **--Amber, t24a**

The women of this study have many interests outside their jobs that, on reflection, seem almost like antidotes to their daily intense immersion in the technical. Frequently, I heard the women say that one thing they dislike most in their jobs is the fact that no matter how interesting, enjoyable, complex, or intricate a given project is, sooner or later, there comes a "crunch time:"

> It seems like things get very crunched at times and I work on projects that seem to be high-profile kinds of things so it ends up being a lot of overtime. So I don't know. I think I'm getting [to be] a workaholic, but . . . I'm kind of in a situation that requires it. I definitely love vacations and time off. . . . I would much rather be riding my bicycle or going to a movie. I like rest and relaxation--things like that--much more than I would like to work. I feel it's preventing me from doing things I like to do (Chris, t13b).

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"I don't like the unrealistic schedules," Dale said (t17b). Amber referred to this phenomenon as "rat mode," about which she said, "I don't like the fact that there are times for everyone, and for some people it's all the time, when the bottom line becomes the most important thing, and people get ignored. Quality gets ignored" (t13a). The women's extra-professional activities seem to represent a *resistance* to "rat mode." The women seem to strive for well-rounded lives, and the money they earn is applied to creating this balance. They see their professions as critical to having the amount of income necessary to exercise their extra-professional options.

It was striking to me (and it resonated with my own experience as a computer scientist working in an engineering environment) how often in my interviews I heard women say they do not own a computer of their own, and do not care to play with computers at home, receive computer literature at home, or read and think about computer technology outside the workplace. Eileen checks email from home before bed and again before going to work in the morning as a precaution against unpleasant surprises upon arrival at work in the morning, but otherwise rarely uses her home computer, though she is glad to make it available to her third grade son on occasion. Dale's comment was that she doesn't want such stuff "contaminating" her environment. Like Eileen and Amber, she has a computer at home, but rarely uses it. Amber recently replaced her old Macintosh with a Pentium-based Windows system. She thought she would use her new system more than she used her old one. She even bought the computer game MYST thinking she would enjoy playing in its "virtual" environment. But she says she hardly ever touches the game or the computer itself. There are many

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more compelling things at home that she prefers to engage with: her son, her husband, the dog, the garden, long walks on her own ten acres, or walks with neighbors. She used to be involved in activities for social justice. She points out the irony that her technical job takes energy that can now no longer be applied to what used to seem like pressing social issues. Rather, these issues must be relegated to agencies with paid staff.

In this section, I discuss some of the outside interests and activities of the women in the study. Dale has many different and unusual interests and activities outside work, which she talked about at some length. Eileen exuded energy and enthusiasm as she talked about both her work and how she expresses her extra-professional interests. Tamra and Stella were studying to become licensed massage therapists. About half of the women are involved in sports or various other regular physical activities. And many of the women are involved in caretaking activities, both at home and in their communities.

Dale Anthony

As much as Dale likes her work, she appreciates setting it down and walking away from it at the end of the day. She finds she doesn't use her own home computer, doesn't care about computer games, is "more interested in animals, the outdoors, and relaxing" (Dale, t22a). She doesn't want to "sit around home and read computer magazines and books; I'm just not that interested," she says (t22a). "I don't want it contaminating my home environment" (t22a). She wants to keep her work interests "separate from home. . . . I have other things to live for" (t22a). When I asked Dale if, in her

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work, she feels pride in being part of something important, she replied that it is "not that important" (t22a).

Dale Anthony lives on several acres of land, with woods, a lake, animals and, during spring and summer, several hours' worth of mowing each week. She has named her place "Anthony's Woods," after her father, whose name is Woodrow Anthony. Almost every year for the past ten years or so, Dale has spent vacation time scuba diving and/or ocean sailing. She often goes by herself, and develops friendships with the others on the trip. Dale has also become involved with Fight Back, an organization which teaches self defense to women. Her experience with the organization has been profound.

> It is shocking when you first go in there and all these women are standing around and you realize they're teaching you these simple basic things that any person on this planet should know but none of the women in the room know it, because women are not taught it. Males know it; females don't know it. . . . They teach you a set of scenarios and then later you get surprise attacks and you have to figure out what to do--which scenario, which pieces of which scenarios to do. And it's really good. And it's this fantastic emotional bonding with all the women (t23b).

The experiences Dale has had with her classes with Fight Back have inspired her to write poetry, something she did years ago but had set aside. In the past, Dale has also worked with Habitat for Humanity, building houses for the homeless and the poor. Dale speaks of these activities, which build a spirit of community and solidarity, with a passion I don't hear in her discussion of her work.

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Eileen

Eileen started college with "a scholarship right out of high school" (t17a). While she took a wide variety of courses that interested her, including mathematics, she began to develop a major in fine art. After two or three years, realizing that friends who were graduating with art degrees were working as waitresses, barely able to support themselves, she became interested in computer science, which "came easy" (t30a) to her. She graduated from college with a double major: fine art and computer science.

While studying computer science, she "liked the systems level--the assembly level--the machine language stuff" (t30a). She used her knowledge of operating systems and assembly language programming in her first computer job (approximately two years), and the expertise she developed there has also been relevant in her work with her present company (approximately twelve years).

Outside of work, Eileen has a wide variety of interests, spanning family, the arts, and fitness. Her seven year old son is of primary concern to her now. Her husband's work frequently takes him out of town for days, sometimes weeks, at a time, so he is not always able to share the transportation and babysitting responsibilities for their son, though he shares all these things when he *is* in town. It is important to her to spend as much of her free time as possible with her son while he is young; otherwise, she comments, "Why bother [having kids]?" (t30a) She feels his parents should be there to do homework with him, to see to nutritious meals, and simply to be physically present with him in his own home. Before he was born, however, she enjoyed playing volleyball and softball, riding bikes, walking, and jogging. She still jogs regularly, at lunch times and on weekends. She

also used to paint and throw pottery, activities for which she is unable to find time now. She continues to enjoy attending art exhibits, and going to the movies, though not as frequently as in the past. Her husband too enjoys these things. They occasionally meet while he is on the road to see special exhibits at art museums in distant cities. They are familiar with many of the local galleries.

Her artistic interests are expressed in Eileen's job as well as in her private life. She hangs art prints in the computer lab that the associates in her division share. She even went to the trouble of applying for and obtaining official permission (approximately a month-long process) to hang some pieces from her personal collection in the hall outside her office after her most recent promotion, when she was given an office, two walls of which are all windows. She chuckles when she tells that story, imagining her co-workers saying, "Oh, god, there she goes" (t30b). She also enjoys entertaining and planning parties, and has been involved in planning the company Christmas party. But her interests in the art world are not shared by her fellow technical employees as enthusiastically as by her husband and friends outside the technical workplace. "I was thinking of renting out [for the Christmas party] one of the galleries down there [in the 'artsy' area of town]. I'm thinking it'd be cool, you know, cocktail hour, sitting around [amidst the interesting and beautiful art]; and he's (the VP with whom she has been planning the company Christmas party) like, 'Now who's this for? Who in the world's going to appreciate this?' And he's right. . . . I do keep always trying to do things like that . . . It's just kind of funny" (t30b).

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Massage

Two of the women in the study were attending massage school when I interviewed them. They also work with the same company, are the same age (20s), are college friends, and share other non-technical outside interests besides the interest in massage therapy. Their names were given to me by a 3rd person, however, not by each other. They had not decided to attend massage school together. They were surprised when they found out that independently they had both researched the possibility, applied to, and made the decision to begin massage school. One (Tamra) seems more gregarious and less satisfied with her technical career than the other (Stella). Both are also athletic and participate in competitive team sports. Tamra had received an athletic scholarship to play softball in college.

Sports

Many of the women in this study are involved in sports and other physical or athletic activities. Particularly among the younger women, softball was frequently mentioned. Tamra, Chris, Stella, Sara, and Jane play softball in leagues through their companies or their cities' recreation departments. Amy, Ann, and Eileen also used to play softball, but have become committed to other things in recent years. Still, they work out regularly. Ann and Amy do aerobics as do many of the women. Eileen jogs regularly on her lunchtime. Chris jogs and has even run marathons. Tamra, Stella, and Amber jog also, though with less regularity than Eileen and Chris. Bike riding is another frequently mentioned activity, and is enjoyed by all these women. Sara and Ann mentioned that they participate in organized large-group and long-distance rides. Chris plays basketball and racquetball

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frequently. Volleyball and hiking were mentioned frequently as extra-professional activities by many of the women. In addition to these traditional sports activities, many of the women consider gardening an important physical activity in their lives. Amy and Ann have large vegetable and perennial gardens; Amber and Dale each have several acres to maintain; and Chris, Tamra, and Eileen each enjoy putting energy into the care of their yards.

Helping People

It is remarkable how many of the women put "helping people" at the top of their discussion of what they like or get motivation from in their work. Some of the women were previosusly in "helping" professions, such as teaching, prior to their computer science careers. These women say they switched to their current careers for financial reasons and to reduce the emotional strain they experienced in connection with their working lives (Amber, Dale). Many of the women do "helping" work outside of their jobs, including caring for family, studying massage therapy, and doing volunteer work for organizations such as Hospice.

For many, interests centering around church or family have high priority. Justine and Kathy meet with fellow church members regularly and donate time to church causes and social activities. Gladys and Ann have grown children with whom they maintain fairly regular contact. Amber, Cecilia, Eileen, and Michelle have school-aged children for whom they are both physically and emotionally on-call 24 hours a day. Jane has assumed the family responsibility of regularly assisting an elderly aunt with housework and trips to stores, doctors, and other destinations. Such commitments to

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those they care about, those with whom they share special bonds, are of vital importance in these women's lives. Some of the women talked about volunteer work they have been involved in outside of church and family. Amy, who reads and uses the library voraciously, has helped adults learn to read. Kathy, who is interested in nursing, possibly as a future profession, finds tremendous satisfaction in regular volunteer work with Hospice.

Diversity, Education, and Socio-Economic Background

> The other thing that I really like a lot is the diversity.... My old group was wonderful. I had 25 people and the diversity was just--probably half of those people were women. It was a little United Nations every time we got together.
> --Amber, t13a

> The one thing that I like about engineering ... is that there is no class ticket to join. You don't have to [be a] member of the middle class.... You could be poor or you could be middle class. Now, you have to have some logical abilities to think, and be willing to put in some very hard work.... It's kind of an opportunistic kind of job.... To me it's a ticket for a lot of people that are either poor or lower middle class or middle class to be able to make decent money.
> --Cecilia, t31b

The women in this study talked in terms of valuing the diversity of people in their technological workplaces. As women in male-dominated professions, they valued their own inclusion among the men, and had a sense of having accomplished something noteworthy in gaining admission to the world of technological endeavor. On a certain level, they all felt their technical expertise is recognised and respected by their peers of all genders,

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races, and cultures. They take pride in belonging to professions and companies at the forefront of scientific and technological activity, as well as social responsibility--in the inclusion of members of groups which have, in the past, been overlooked, underrepresented, and/or altogether excluded from prestigious or influential careers. They are particularly pleased with the income their professions afford them, and this came up in discussions in ways that suggest they perceive an identity relation between technical work and "decent money" (Cecilia, t31b).

Diversity--other than women

The inclusion of women isn't the only aspect of diversity the women discussed, though it is the main one. Eileen told me about a blind man who works in a highly technical capacity, doing computer programming in her company. The company has provided him with the equipment he needs to do this. Dale told me about an African American man in her chain of command who has implemented exciting new ideas at her company, "promotes and hires women and minorities, you know, at a--you know--well, I guess you could say, at a *normal* rate--which is more than most people" (t17b), and has engaged the support of upper management and been promoted numerous times. Dale also noted that she has met several Hispanic women working in technical capacities in her company.

Michelle talked about the diversity and mentoring programs which her company has put in place and she has participated in. One program she participates in designates safe places at work for lesbian, gay, and bisexual employees by distributing small magnetic pink triangles that employees display on the frames of their office doorways. Another program she is

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involved in teams up women and members of minority groups with experienced employees in working groups other than their own, so the new people can learn the company ropes. One Asian man, in particular, chose her to mentor him through his quest to earn promotion into management, and she found she needed to teach him how to earn recognition for the work he did, and how to communicate at work in ways that are socially acceptable within the company.

Diversity--women

For the women in this study, however, the primary diversity consideration was their own inclusion as women in an environment which is dominated largely by men and in which they can too often seem invisible. Some of the women gravitated toward groups that had a relatively high percentage of women. Chris is one such woman. She has been promoted since transferring within her company from her old group to a group with a few more women, a woman manager, and a lot of visibility and recognition for excellence within the company. Amy, also, at one time transferred to a group that had a relatively high percentage of women. The work her new group was responsible for was somewhat less technical than the other work being done in her company. She eventually transferred back into a technical group in order to maintain her technical competence.

Some of the women seemed not to mind being among so many men and so few women. Tamra, for instance, is the only woman in her immediate workgroup of five programmers. With approximately seven years experience with her company, she has less status and lower pay than the men in her group, all of whom have been with the company more than twice

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as long as she. She enjoys working with them, however, and finds sports to be a point of common interest and banter. "I can talk sports with the guys, and it's almost like I'm accepted as one of the boys, if you know what I mean" (t6a). Jane said she gets along better with men than women. To Helen, nothing in her current male-dominated profession is worse than the pressure of the deadlines she faced in her former career as a journalist. Dale said, "In some ways I suppose it might be a little bit of a disadvantage to be mostly working with men, but that's the only way you can make any money, so it is worth it and it's not that big of a disadvantage. You get used to that very easily" (t22a).

Diversity--women managers

Some of the women were the first or only woman hired into their respective groups when they first came to work for their companies, and have become involved in increasing the presence and recognition of women in their companies. This is true for Cecilia, Eileen, and Michelle. All three are now managers.

Cecilia talks about how hard it was being the only woman among men who resented her presence when she started with her company. She remembers management at that time being concerned with identifying, challenging, and encouraging women to excel and to achieve promotion to management.

> I was decent technically. I was also, quite honestly, in the right place at the right time frame. Okay. Um. They didn't hardly have any women technical managers. I mean, zero. I don't know if there was any. Okay. And when I hired in to [my company] it was like 35 men in this one department. And they had no women. . . . And ever since I was there, there was, um, my boss' level type people around who were saying,

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"We've got to challenge these women. . . . We're going to encourage them to become technical managers" (t31b).

Michelle remembers becoming the twelfth woman manager among approximately 700 technical employees at her site within the company. She remembers attending the first annual women's symposium held within her company, and she remembers being asked, by the highest level woman manager then in her company, to become involved in a company program for mentoring new women in the company:

> I said, "Oh, I don't have time." I was busy. I was working until about 1:00-2:00 in the morning. (You have to do 60 hour weeks before you learn that you don't have to do 60 hour weeks.) And I said, "I really don't think I need to go anyway." I didn't get it at the time. She said something that sort of stuck with me and made me think. You know how people drop those little tidbits on you now and then. What she said is, "Well, *you* may not need it, but there are so few of us, that there are a lot of women around here who need you to be there for them, because we all need to be role models (t27b).

Michelle had long worked almost exclusively with men and had come to feel most women she encountered were "catty" and unpleasant (t27a). When the first time arose for her to interview a woman for a job, she had misgivings about her ability to be objective:

> I get promoted to supervisor, and now all of a sudden I've got to interview a woman for my group and I am going through all sorts of inner searching here. I didn't know how I felt about this. First few people that come to get in the group are men—no problem. Then all of a sudden a woman applies and I'm going, "Oh, shit." And that was a real soul searching moment for me in the sense that I had to kind of acknowledge—you have to acknowledge that you have biases before you can deal with them, right? Well, I knew I had them. That wasn't the issue. But actually trying to figure out how I could deal with them, and then doing it, was a challenge. Anyhow that was another hurdle successfully achieved. Actually in that particular group I wound up with about half of it being women before it was over and we all had a wonderful time. That's probably the favorite work group that I've ever

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had since I've been here was that group. I think it wasn't because it was half women and half men, but it was because it was the only one I've been allowed to build from scratch, so it was real compatible people (t27a).

It is a point of pride with Eileen that the all-male group she was hired into in her company has grown in size and reputation, and is now approximately one third women. Eileen's current position in her company is just under that of vice-president. She was initially hired into an all-male group of programmers. She was associated with that group for nine years, and was promoted to management of the group. She now heads the division the group is in. The managers she has had have always been men.

In her hiring practices, Eileen maintains, she has always tried to focus on finding the best person for the job. She points out that she sees far more men's resumes than women's: "The resumes that I--we--received are mainly male. I didn't recruit the women that I got. It just happened that way. I just looked for . . . the best candidate" (t17a). Eileen suspects that her experience of being able to hire a number of good technical women "has to do with the fact that [I am] a female manager" (t17a). She said, "I hired a few women and then . . . women see that women like a certain group and then they--we had a lot of internal transfers. . . . I mean a lot of women who interviewed with me internally said that, you know, they had heard . . . 'You [are] good to work with.' And they had come from bad situations" (t17a).

The group Eileen formerly managed has been split into two groups. She promoted two men into the manager positions of these groups. And they have each hired one woman since. "They have the same attitude [as I]," she says. "And I don't know if that was because that was my attitude but, I mean, nobody in that group thinks about, you know, sex or color or gender or

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anything. It's just, you know, 'Who looks like they'd fit?' Because we look at personality too" (t17a).

Diversity--age

Dale, a woman in her 40s, noted that the women she encounters at work are nearly always younger:

> Something I've noticed up here is that I look around and I think, 'Where are my older sisters in this workplace?' They're not here. . . . I can only think of one [woman colleague] that's older than me and she's the new department head, the Black female department head in my department. And all the other women, including the managers . . . in all the meetings usually I am the oldest. Sometimes I'm the oldest *person* . . . except for this one woman (t23b).

Career and Educational Diversity--the Older Women

Except for one, the older women in the study did not start out in their current technical professions. About half the women in this study were under 40, the rest over. One woman was in her 50s. Cecilia is the only woman over 40 whose path to her current profession was direct. She earned her Bachelors degree in mathematics immediately after high school. Her first job was a programming job, which she found she was good at. So she studied computer science, got a Masters in it, and has been working with her present company ever since.

Amber and Dale earned undergraduate degrees in psychology immediately after high school, then entered careers in teaching. Amber taught as a substitute in a large city, taught in the Head Start program, and headed an inner city day care program. When she was pregnant with her son, she decided she wanted to find work that would be less emotionally draining than her work with kids from disadvantaged homes, so that she could

reserve her emotional energy for her own child. It was during this time that, standing in the grocery store checkout line one day, she happened to see an article in *Woman's Day* magazine about computer technology as a career path for women. She signed up for a programming class at a nearby junior college, earned an Associates degree in computer technology, got a job with her present company, and eventually earned her Masters in computer science.

Dale taught severely emotionally handicapped children for many years. Around the time burnout became an issue for her, she came across a flyer on a public bulletin board suggesting that computer science is a good career for women. After taking programming courses at night for a year, she quit her teaching job, sold her house, and became a fulltime student, earned a second Bachelors degree in two years, and took a job with her present company. She has Masters degrees in human learning and education, and is in the process of getting her Masters in computer science.

Michelle earned her Bachelors in mathematics education. She did some teaching, but raising three young boys took priority shortly after college. While her children were young, she started into graduate school. She drifted fom mathematics to industrial engineering to computer science. Ultimately, she finished a Masters in industrial engineering, took a job with her present company, and then immediately finished her Masters in computer science.

Kathy, Amy, and Ann started college right after high school, but dropped out due to distractions and lack of strong motivation to continue. Kathy and Amy did secretarial work for a few years before regaining their drive, choosing a major, finishing their Bachelors degrees, and getting computer science jobs. Ann raised a family, worked in her husband's company for awhile, got a job with the post office, and eventually finished

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her Bachelors in statistics at night. After that, she got a fellowship, quit her job, got her Masters in computer science, and landed a job with her present company.

After high school, Marie didn't know what she wanted to major in in college, so she joined the army. There, after some testing, she was trained as a computer operator, and she found she liked the work. After the army, she found an operations job with her present company, earned her Bachelors in computer science at night, and has been promoted several times since.

Gladys took a clerical job with her present company shortly after high school and has worked there ever since. Over the years, she found she had an affinity for some of the technical work, and was eventually promoted into a programming position. She is in the process of earning her Bachelors in computer science.

Career and Educational Diversity--the Younger Women

Among the women in their 30s and 20s, Helen is the only woman who started out in a profession other than computer science. Her first Bachelors degree was in jounalism, and it was while she was working as a journalist that she became interested in the workings of the computers that were being introduced into her field. Her interest in the computers at her newspaper led her to coursework in computer science. She earned her Bachelors in computer science at night, then took a job with her current company.

Eileen and Erin had double majors as undergrads, one technical and one not. Eileen's Bachelors degree is in computer science and fine art. She started out majoring in fine art, and took up computer science later in college, when she became concerned about income-earning prospects. She continues

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to pursue her interests in fine art in her leisure time. Erin has a Bachelors in mathematics and French. Since getting a job with her present company, she has earned her Masters in physics and is working on her MBA. Sara has a Bachelors degree in computer science and mathematics.

Kay and Justine earned their Bachelors degrees in industrial engineering. Justine has also earned her Masters in computer science. Kate earned her Bachelors in engineering physics and her Masters in computer science. In fact, Kate stopped just short of taking the candidacy examination in her Doctoral program in computer science. Chris, Jane, Tamra, and Stella earned their Bachelors degrees in computer science.

Tamra and Stella are in the process of studying massage therapy and working toward state licensure (LMT). Neither has decided how she will incorporate this new skill into her work life. Tamra, in particular, expressed a sense of conflict about this. While she likes her current technical work, she is uncertain that it is a lifetime profession for her.

The women in their 30s and 20s in this study all earned their Bachelors degrees directly after high school. Only one of them (Eileen) has children, whereas 5 of the older women have children. Eileen, Chris, Kay, Justine, and Sara all had computer science/engineering jobs with others companies before coming to work with their present companies.

Education--Encouragement

While the women in this study arrived at their professions via many different and sometimes circuitous paths, they all left high school knowing that they were college bound. They all knew college was an option for them, and most of them "knew" that not going to college was not an option for

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them. Dale remembers that her mother was adamant about it: "My mother was a secretary and she had been brought up even more traditionally than I was. She wanted me to go to college. I was always going to college. There was never any doubt" (t22a). Eileen says that she "knew all along--just because of [her] up-bringing" (t17a) that she would go to college and "have some kind of a decent job. But there wasn't any big plan with that" (t17a) in terms of what she would study or what her career might eventually be. Both of her parents had college degrees. Her father had an accounting degree and worked as a CPA. Her mother had a degree in sociology and worked as an elementary teacher. Her grandmother, as well, had a college degree and was a school teacher.

Most of the women in the study had parents who had college degrees. Often, their parents were teachers or engineers, or there were teachers or engineers in their lives, among their relatives and neighbors. Sometimes, too, the women's teachers in school made strong impressions on them and gave them special encouragement. Even those whose parents didn't have college educations felt a certain pressure at home to do well in school and succeed by the standards of society.

Amber's parents didn't have college degrees; they were farmers. Her mother had been the valedictorian of her class and had wanted to go to college, but the depression interfered. Many of her aunts and uncles were teachers, however, and when Amber was older, her mother worked in the cafeteria at her high school. Education was strongly emphasized in Amber's home growing up: "I grew up in a family where education was very important and I studied very hard and was a good student [and did well] in everything" (t24a).

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Cecilia's mother was also high school valedictorian. Cecilia grew up in a small town, remembers that it was important to her to be good and to please her elders, and became valedictorian of her own high school graduating class.

Ann's father was determined that she would grow up to be a doctor. She still feels a twinge of having not quite lived up to her potential, and thinks she may eventually return to college to earn a Ph.D. in psychology, if not in something technical.

Kate's mother was an English teacher and her father was a mechanical engineer. Kate remembers browsing through her father's college physics textbooks when she was about ten years old and thinking about her own future: "I decided--I remember deciding around fifth grade--I was looking through my dad's like college physics books--not understanding a word, but thinking, 'This looks neat.' And that was fifth grade. You know. That's pretty early. So I always--I started to like work harder in those kind of classes" (t15a).

Tamra's father taught middle school mathematics and science. Tamra notes that these were her favorite subjects as well. Until high school, Tamra had thought she would pursue a career in teaching. However, her older brother earned a Bachelors degree in education in the 1970s and was unable to find a teaching job, so he got into the insurance business, which he has never really liked. Her mother encouraged Tamra to consider choosing a college major that would be more marketable than teaching had been for her brother and more lucrative than teaching had been for her father. She pointed out that Tamra could:

> make a little bit more money [in a computer related field than in teaching]. She [said], 'Computers [are] the way to go.' And fortunately, it interested me. It had something to do with mathematics and science,

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which was really up my alley. . . . I started taking computer classes in high school. . . . I thought, 'Well, I like this, and it's got good job potentials when you graduate.' So I just went for it. . . . [It] never entered my mind to even change majors. [I] just thought, 'This is the way it's gonna be.' . . . It just so happened that I liked it, which was nice (T7a).

Chris' experience is somewhat different than the experience of most of the women in the study. Neither of her parents went to college. "My dad was working three jobs. So I definitely thought I wanted to do something different here. They were both very supportive of any decision I made and they provided me with the ability to go to college in that respect"(t13b).

Education and career--earned it?

There is a sense in which these women were all somehow "predestined" to have the lucrative technical careers they have. Several of them talked about the hard work they put into earning their career. Yet they grew up in a world in which there were assumptions from their earliest awareness that they were to have positions of power and influence and expertise in their adulthood. None of the women in the study were from outside the middle class, despite the comment Cecilia made:

"The one thing that I like about engineering--okay--in general--is that there is no class ticket to join. You don't have to [be a] member of the middle class. . . . You could be poor or you could be middle class. Now, you have to have some logical abilities to think, and be willing to put in some very hard work. . . . It's kind of an opportunistic kind of job. . . . To me it's a ticket for a lot of people that are either poor or lower middle class or middle class to be able to make decent money" (t31b).

The assumption of a good career, a good income, and a sense of control over their lives came with their experience and their family upbringing. They

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assumed a right to these things. Even though society had previously barred women from technical endeavor and women had been thought to be incapable of science and mathematics expertise, it did not seem, in their interpretation, that barriers had been placed in their paths. Furthermore, many of them also assumed the right to be dissatisfied with earlier professions, and to change professions. They knew they had access to the resources required to develop a new area of expertise, including money or other financial means and the support of family and friends. Certainly, the work of Lucy Sells (1973) and others led to an openness of education and industry to these women. Their intelligence and the hard work they have done in their schooling and in their work do not, alone, account for their inclusion in their technical professions.

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CHAPTER 6

REFLEXIVE TALE

In qualitative research, such as this, a "reflexive tale" is an important part of the write-up (Lather, 1991, 1993; Funow & Cook, 1991)). It is a response to the postmodern crisis of representation (Glesne & Peshkin, 1992; Lenzo, 1995; Richardson, 1988, 1994). It is an acknowledgement that the research process and the outcomes of research are always influenced by contextual and cultural factors (Acker, Barry & Esseveld, 1991). In this particular case, it is an acknowledgement that I am *in* this study in a profound way, both as researcher and researched.

Reflexivity. Funow & Cook (1991) define reflexivity as "the tendency of feminists to reflect upon, examine critically, and explore analytically the nature of the research process" (p. 2). This involves giving consideration to my own involvement in my study and my reactions to it. Such self awareness and reflection can bring about "creative insight that is generated by experiencing contradictions" (p. 3).

Postmodernity. Postmodern research places the absences in our knowing, the conflicts, contradictions and paradoxes, in the foreground. Laurel Richardson (1994) says, "The core of postmodernism is the *doubt* that any method or theory, discourse or genre, tradition or novelty, has a

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universal and general claim as the 'right' or the privileged form of authoritative knowldge" (p. 517).

Contextual and Cultural Factors. About qualitative research in this postmodern world, Steiner Kvale (1994) writes: "there is a focus upon interpretation and negotiation of the meaning of the lived world. . . . [T]here is an emphasis on the local context, upon the social and linguistic construction of a perspectival reality where knowledge is validated through practice" (p. 5). And Richardson (1994) writes:

> Postmodernism *suspects* all truth claims of masking and serving particular interests in local, cultural, and political struggles. . . . But a postmodernist position does allow us to know 'something' without claiming to know everything. Having a partial, local, historical knowledge is still knowing. In some ways, 'knowing' is easier, however, because postmodernism recognizes the situational limitations of the knower. Qualitative writers are off the hook, so to speak. They don't have to try to play God, writing as disembodied omniscient narrators claiming universal, atemporal general knowledge; they can eschew the questionable metanarrative of scientific objectivity and still have plenty to say as situated speakers, subjectivities engaged in knowing/telling about the world as they perceive it (pp. 517-518).

Negotiating Meaning

I am entangled in this research project to the extent that the study is about women who do computer science work similar to that which I am qualified to do and have done. I have written of my own experience as a woman computer scientist working in an engineering environment as a prior ethnography to this study (see Chapter 3).

The contradiction that comes through in the text of this dissertation was something I lived as a computer systems analyst working in an engineering environment for over six years. In fact, I still live contradictions

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in my role as graduate research associate with OSU's University Technology Services. On the one hand, the technology to which we in the technical realm have access is exciting: for its novelty; for the potential it provides to improve communications with family, friends, and associates; for the potential it provides to improve access to information; for the sheer speed and "efficiency" of operation and analysis. It is fun being in a position of knowing *how* these technologies work. On the other hand, however, as each successively higher standard of computer technology is adopted at the University, the cost of keeping up with the innovation rises in terms of time and mental energy, as well as money; some people are excluded from participation due to the costs; and older technologies are discarded, laying to waste enormous human and material resources. In addition, each successive layer of technology seems more to emphasize keeping people from knowing how the technology/system works.

The contradictions I experienced in the process of this study began with the review of literature and continued through the interviews. I struggled over how to present so much seemingly disconnected information. Even though I had decided early on to to present the literature about women in science and technology as a collection of disconnected yet interconnected stories, I was overwhelmed with the inconsistencies within and across interviews with the women who participated in the study. One of the earliest approaches I took with the data was to make lists of the inconsistencies, contradictions, and paradoxes that frustrated my attempts to make sense of the data. Discussions with my writing group helped me articulate these contradictions. Discussions with my advisor, Suzanne Damarin, helped me find substance in the *condition* of inconsistency, contradiction, and paradox

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throughout my data. But perhaps it was in an offhand comment to Jane Fraser, of my dissertation committee, that I began to be able to embrace contradiction as thematic and central and valid in this dissertation. I had run into Jane and a former doctoral student of hers during an emergency evacuation of our building on campus. As we stood in the rain awaiting the re-entrance cue, Jane's former student described the "findings" of her dissertation research. Then the conversation turned to my dissertation research, and I heard myself say, "The only pattern in *my* data is that there *is* no pattern!" That comment still echoes in my mind. Indeed, it was through confrontation with contradiction that the "creative insight" of which Funow & Cook (1991) write was achieved in this project.

I have conceived of this dissertation as a collection of stories about the relationship of women to science and technology. I have explored how women in science and technology experience the technical realm. I have told many different tales, using different styles of writing. Within Chapter 2, the literature review, the fourth story, "Science Defined as Male," is written in a style by which I attempt to keep pace with a style used by Evelyn Fox Keller (1985) in her book, *Reflections on Gender and Science.* It makes liberal use of quotations from my source (Keller), as well as incorporating quotations within quotations, as Keller did in her book. This style differs greatly from that of the other "stories" in Chapter 2. It is different also in that it concentrates on only one piece of work, reviewing it closely, rather than pulling many facts from numerous authors or citing many authors who address the same or similar issues.

In Chapter 4, the collection of profiles, the styles of the individual profiles vary. The profiles of Amber and Dale Anthony, for instance, are

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story-like, conversational narratives, whereas the profiles of Kate and Tamra are displays of notable quotations, framed by narrative. Eileen's profile, written last, is written in a combination of both of these styles. The variation in the styles of these profiles has as much to do with the evolution of my own process of writing them, as with the content of the data and the (conversational) feel, or style, of the interviews, which itself was surely influenced by physical setting as much as by the personalities involved. (Interviews conducted in the workplace, for instance, had a certain formality to them that was generally not present when I spoke with women in their homes. Telephone interviews lacked the warmth of a face-to-face conversation, in which meaning can be communicated with body language and facial expression, as well as spoken words.)

Variation in styles of research write-up is not unprecedented. Sociologist Laurel Richardson (1993) has presented her work by means of a poem--"Louisa May's Story of Her Life"--and an ethnographic play--"The Case of the Skipped Line"--as well as prose. She is concerned that the way social science research is written up "prefigure[s] judgments about the validity" (1993, p. 695) of the work. She eschews "formulaic write-ups" (1988, p. 200), and instead is interested in exploring ways of writing that communicate context, both that of the researcher and that of the researched.

Validity

This dissertation is not about *social* scientists. But the methods of social science are being applied here to the study of how women in *technological* science experience the realm of science and technology, in which they are immersed. The literature about doing social science is

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concerned with validity, or trustworthiness. How might I to address the issue of the validity of my work in a substantive way, in a way that is not hackneyed or superficial, in a way appropriate to the study I have undertaken and written up? It seems that nothing about this study, especially in light of the way I've written it up, would qualify as scientific to the women in the study.

The topic of validity in qualitative research in these postmodern times has been addressed by Kvale (1989), Lather (1986, 1991, 1993), Lenzo (1993), Richardson (1988, 1993, 1994), Scheurich (1991, 1992) and numerous others. It is a topic that is not easily resolved by formula or algorithm. I think the validity of this study is best addressed by Richardson's concept of crystalline validity. In the past, "triangulation," demonstrating the use of multiple methods of approaching a study, was a method used to convey validity. Richardson (1994), however, prefers the image of the crystal to that of the triangle:

> I propose that the central image for "validity" for postmodernist texts is not the triangle—a rigid, fixed, two-dimensional object. Rather, the central image is the crystal, which combines symmetry and substance with an infinite variety of shapes, substances, transmutations, multidimensionalities, and angles of approach. Crystals grow, change, alter, but are not amorphous.
> Crystals are prisms that reflect externalities and refract within themselves, creating different colors, patterns, arrays, casting off in different directions. What we see depends upon our angle of repose. Not triangulation, crystalization. In postmodernist mixed genre texts, we have moved from plane geometry to light theory, where light can be both waves and particles.
> Crystallization, without losing structure, deconstructs the traditional idea of "validity" (we feel how there is no single truth, we see how texts validate themselves); and crystallization provides us with a deepened, complex, thoroughly partial, understanding of the topic. Paradoxically, we know more and doubt what we know (p. 522).

My claim, then, is that there is crystalline validity to this study. The views we get of women in science and technology through a review of the literature are multifaceted. The lives of the women who participated in the study are multifaceted. My own involvement in the study in a somewhat peripheral way contributes a(n/other) facet(s) as well. And through the profiles of Chapter 4 and the exploration of the contradictions and multiplicities in Chapter 5, yet more facets reflect light on the subject of women in the technical realm.

Notes on Consistencies

In spite of the many conflicting and contradictory fac(e)ts encountered in this study, there are some interesting consistencies between the literature and the data. Perhaps the most obvious parallel is that in the literature, and in the study, women have been both insiders and outsiders with regard to the technical realm. It is also the case that, to a very great extent, the women who pursue interests in science and technology are women who are born into a certain assumption of personal privilege. They are often encouraged in their technical endeavors by the men in their lives. In earlier centuries, women learned the technical at home by working with their fathers or brothers, or by listening in on their brothers' sessions with tutors, or sometimes even receiving tutoring themselves.

In the cases of the women in the study, they grew up in post World War II times, when many parents told children that anything was possible for them. But more importantly, they grew up in homes where education was highly valued, and it was assumed and never questioned that a college education and a career was inevitable in their lives. In addition, these

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women received encouragement from fathers, teachers, and supervisors at work. The availability of education and encouragement crystalized technical interests and abilities of women in both the literature and the study.

There is evidence of the conflicted identity that Keller describes for women in science and technology. Although I did not give examples in Chapter 2, the literature is replete with stories of women of scientific and technological knowledge and power who were unable to participate in public scientific discourse, and who became sickly (thought now to have been depression) at an early age, yet continued to pursue their scientific or technological interests, as their ailing health permitted. Despite their persistence at working inside the mathematical, scientific, and technological discourses, they were nonetheless outsiders in many regards, as were the women in this study.

The women of this study are the successes prefigured in the fifth literature story of Chapter 2, "Mathematics, Education, and Gatekeeping." Having passed through the "mathematics gate" to their computer science professions, with grades, statistically speaking, as good as or better than those of their male peers in school, they still show mixed signs in terms of self-confidence and in terms of their sense of "belonging." They see themselves overlooked and ignored sometimes in their work. They cultivate alternative interests outside of the workplace. They express concern about their ability to keep up with the changes in technology. But they insist on maintaining their right to participate in the privileged technological arena. And they cherish their identities as women with technical expertise.

As the general access of women to education has increased over time, the population of women receiving encouragement to study mathematics

and the sciences has increased. As women gain insider status within the technical realm, however, it is always partial. What seems to have happened is that, despite laws and policies regarding the inclusion of women in technical education and in the technical workplace, the social constructions remain intact under which exclusion of women was institutionalized and under which the laws and policies for inclusion of women were produced. And thus women remain outsiders. The modified institution of schools educates women to insider status without addressing the outsider status that is socially constructed in the way Keller (1985) has explicated.

The Pipeline

Particularly in literature focused on the goal of increasing the numbers of women in technical fields, there is a broad discussion of the numbers of women "in the pipeline" and of keeping women "in the pipeline" to these professions. For nearly half of the women in this study, however, the "pipeline" is the wrong metaphor. For them, the technical profession is not their first; not something they pursued immediately after high school. Rather, it is an outcome of later developing interests and schooling, a destination to which they came later and at their own pace. Their education and experience are broad and varied, and they bring this breadth with them to the technical realm. The pipeline metaphor does not account for them, nor does it accommodate them. And, if indeed it does account for and accommodate the women for whom computer science was the first and immediate career after high school, the pipeline does not account for some of these women leaving or entertaining thoughts of leaving their technical professions.

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With the pipeline metaphor, girls enter at kindergarten or before, and exit at the end of their schooling in a technical position in industry. The pipeline is a delivery system of passive women being washed along from one end to the other. Those who would choose to swim at a different pace, or against the current, slip through the cracks and out of the pipeline altogether. The pipeline metaphor offers no alternative routes to the development of interest in and mastery of (particularly) mathematics (and other technical studies). The pipeline metaphor fails to validate and valorize multiple educational pursuits and career changes. It knows naught of the influence of Women's Day, bulletin board postings, and the examples and encouragement of friends and aquaintances in a woman's life. The pipeline is a one-dimensional metaphor which might more inclusively and representatively be replaced by a non-linear metaphor. Perhaps a more accommodating metaphor would also influence the teaching of mathematics and other technical subjects to be more respectful of multiple pathways to the development of interest and mastery in these subjects.

APPENDIX A

INTRODUCTORY QUESTIONNAIRE

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121 Ramseyer Hall
29 West Woodruff Ave
The Ohio State University
Columbus, OH 43210

Thank you for your interest in my dissertation research and your willingness to support it with your participation. As you may know, I am a Ph.D. candidate in Instructional Design and Technology, in the Department of Educational Policy and Leadership, at the Ohio State University. My overriding research question is, "How do women who are engineers and computer scientists experience their professions?" In this letter I want to outline for you the general procedure I expect to follow in carrying out my research.

In the beginning, in order to facilitate our getting to know each other a little bit, I have a few data gathering activities I would like to run through:

-an introductory questionnaire
-a short taped phone interview—about half an hour
-a site visit, so I can observe the sort of atmosphere in which you work
-the signing (by both of us) of an "Informed Consent" form outlining the research project

We can conduct these activities in whatever order works best. It is my intention to be as flexible as possible. Accommodating you is important to me.

Following the first phase of the research (as outlined above), I will want to conduct extended and more in-depth interviews on tape. I expect these interviews to last around an hour and a half or two hours. You may not want to continue into this phase of my study, and that is okay. I will want to conduct in-depth interviews with some of the participants in the study more than once, and I expect to ask a few to join together for a group interview toward the end of my data-gathering period. I will also be interested in feedback from you about preliminary write-ups as I begin to produce them. However, if at any time you feel you cannot or do not want to continue involvement with my research, and you want to drop out of the study, you need only let me know. There will be no hard feelings.

If you are interested in participating in this research, at least in the beginning, or would like to ask me some questions about it, please contact me by phone (don't hesitate to talk to my machine), email, fax, or U.S. mail. Thanks in advance. Your interest and participation means a lot to me.

Sincerely,

Linda Condron
E-mail: condron.1@osu.edu
Phone: (614) 262-4356
FAX: (614) 292-7081

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QUESTIONNAIRE
WOMEN IN ENGINEERING AND COMPUTER SCIENCE

Part I

1. Name _____

2. Address _____

_____

_____

3. Phone _____

4. Company _____

5. Work Phone_____

6. Fax _____

7. E-mail _____

8. Choose a pseudonym by which I can refer to you in my writing. _____

Part II

1. Education--List the degrees you have completed or are working on:

Degree   Date   Major/Minor   College/University   Location

_____

_____

_____

2. Circle your age range:

     20's   30's   40's   50's   60's   70's

3. Is this (engineering/computer science) your first career? If not, what kind of work did you do previously?

_____

_____

_____

4. How long have you been doing this work?_____

5. How long have you been working with your present company? _____

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6. What other companies have you worked with as an engineer/computer scientist?

_____
_____
_____
_____

7. What professional organizations do you associate with?

_____
_____
_____
_____

8. What special awards and honors, such as scholarships, election to office, funding of grant proposals, etc., have you received?

_____
_____
_____
_____

Part III

In the following five questions, place your answer on the continuum from 1 to 5, with 5 being the highest or greatest extent:

1. To what extent is your job self-guided?

```
|_____|_____|_____|_____|
1          2          3          4          5
```

2. To what extent do you work to carry out someone else's directives?

```
|_____|_____|_____|_____|
1          2          3          4          5
```

3. To what extent is it possible to be completely objective whenever called for?

```
|_____|_____|_____|_____|
1          2          3          4          5
```

4. Do you ever question your own objectivity?

```
|_____|_____|_____|_____|
never      2          3          4          lots
```

5. Would you say you have high self-esteem?

```
|_____|_____|_____|_____|
low        2          3          4          high
```

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INFORMED CONSENT FORM

WOMEN IN ENGINEERING AND COMPUTER SCIENCE

I consent to participate in Linda Condron's dissertation research project tentatively entitled "How Women Who are Engineers and Computer Scientists Experience Their Professions."

The purpose of the project is to gather stories about how women who are engineers and computer scientists experience their professions, and to use these stories in an examination and exploration of the many competing discourses about women and science and technology.

I understand that the research will include a series of taped interviews that may be transcribed in part or in whole.

I understand that in any published documents, my name will be changed for the purpose of confidentiality.

I understand that I will have an opportunity to review preliminary write-ups and contribute to Linda's interpretations.

I understand that I can stop participating in this project at any time.

(Please sign below. I too will sign, agreeing to adhere to the terms stated here. I will then return a copy to you.)

Your Signature_____

Your Name (printed)_____

Date_____

Investigator's Signature _____
                                    Linda Condron

Date_____

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APPENDIX B

TELEPHONE INTERVIEW GUIDE

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Telephone Interview Guide

Women in Technological Careers

1. What is your job, in a nutshell, and on what aspect of it do you place the most emphasis or importance?

2. What do you like about this work?
   Why have you stuck with it?

3. Why did you pursue this career?

4. Do you want to spend your life at this?
   if no: Why not?
   if yes: Where do you see it taking you?
       promotions?
       autonomy?
       responsibility?
       authority?

5. What would you change about your job?
   How could it be a better job?
   What don't you like about your job?

6. What proportion of your immediate work group are women?
   What proportion of your supervisors are women?

7. Do you feel you are treated differently than the men you work with/among? Give examples to support your impression, either way.

8. What observations or advice would you pass along to young women who think they may be interested in pursuing a similar field?

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APPENDIX C

SUBSEQUENT INTERVIEWS GUIDE

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Interview Guide for Subsequent Interviews

(I have collected into this appendix lists of questions that I prepared and/or used in face-to-face interviews over the course of the interviewing. How I used these lists of questions in a given interview depended upon previous conversations, issues that had already arisen, what I already knew about the woman, how reflective the woman seemed, and how much time we had for discussion.)

1. What do you suppose makes you well-suited to this career?

2. What kinds of activities, interests, and hobbies did you pursue as a kid?
3. Were you a tinkerer? What kinds of things did you like to fiddle with?
4. Who tinkered and fixed stuff at home?
5. Did you get involved in those tinkering and repair projects?
6. How does this come into play in your choice of career and in the actual work you do?

7. Did you take classes outside of school as a kid?
8. Like what? Art? Swimming? Dancing? Music? Sewing? Tennis? Museum classes?
8. Did you take hands-on kinds of courses in school? Lab classes? Like them? Good at them? Others come to you for help?

9. When did you first know you were good at the subjects--science, mathematics, and the technical--that eventually got you into a computer science program?
10. Were your friends all science-oriented?
11. Did your family push it?
12. Did others in your family have technical or professional jobs?
13. Which of your parents did you most respect, admire, or choose to emulate, growing up?
14. Did you have any other role models?

=======

1. Did your studies prepare you well for this job? Explain.
2. In what ways was your education inadequate or irrelevant?
3. What was your favorite non-technical course in college?
4. What was your favorite major-related (series of) course(s) in college? What did you like about it?

=======

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1. Did you expect to spend your entire career at (this company) when you started there?
2. Have you ever thought of going elsewhere to work?
3. Have you ever thought of doing some other kind of work instead of computer work?
4. If you didn't do this what would you be doing?
5. If you won the lottery, would you stay with your job at (this company)?
6. If you had the financing to start your own company, what would you do with it?
7. What keeps you there?
8. Where do you see your career taking you from here? (Feel free to fantasize wildly.)

=======

1. In your opinion, is this a good job for a woman? Explain.
2. What are the advantages and disadvantages of this job?
3. Are the advantages different for women than for men?
3. What sort of mentoring have you received? (formal, informal, women, men?) (political undergirding, power structures, showing the ropes,...)
4. What sort of mentoring have you provided to others?
5. Do you assume leadership or authority in any aspects of your job? Explain.
6. Do you hold back in some ways? Explain.
7. How do you see yourself in relation to your work?

=======

1. What do you genuinely admire about the company you are with--and the products and services you provide?
2. What do you find appalling about the world of technology?
3. It seems like more and more, we hear of the negative consequences of technology. How do you, as a technical expert, react to such reports?

=======

1. What project are you working on now?
2. What part do you have to do?
3. What languages do you program in?
4. How much interaction do you have with the other members of the project team?

=======

1. What are some of the strong influences of your company's highest officers?

2. You commented on the phone that the current director of (your company) has a strong orientation toward a team culture, and that some people don't buy into this very readily. How do the reactions break down in terms of men and women?
3. Team culture, hierarchical organization of staff, procedural rules, . . .
4. How does your company define in the broad sense what it does, what its purpose is, how it fits into the broader economy?

5. How would you describe the atmosphere at work?
6. Are there forces which enhance or impede your getting your work done? Explain.
7. What makes your work enjoyable?
8. What are the most trying aspects of your job?

=======

1. Who benefits from the products and services your company provides?
2. Who is excluded from/ doesn't have access to these benefits?
3. Do you ever feel concern about consequences of the work you do?

=======

0. . . . the computer, the database, the technology, the company, the machine, beepers, "on-call", terminal at home . . .
1. Do you ever feel as if you are more a servant to computer databases than you are a free-wheeling human being?
2. Do you sometimes feel like you are merely at the service of machines/databases?
3. Do you sometimes have a sense that you are part machine yourself?
4. Do you ever feel like jobs are so procedurized that it feels too mechanical to be normal/natural for human beings?

=======

1. Let's talk about the environment... Are you concerned about the environmental consequences of technology?
2. Where does this issue connect to the work you or your company does?

3. I sometimes wonder if we haven't mystified technology thus making it seem more important, necessary, functional, etc, thus giving power over to it, becoming dependent upon it and a servant of it.
4. Do you feel important and involved? Do you feel pride in being part of something important? Talk about how/why this is so important.
5. How critical to humanity is the technology you research, develop, or support?

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6. What do you think is so seductive about technology that you and so many others of us are drawn to it?

7. Do you ever question whether the (products and services your company) is dedicated to creating and maintaining really mean so very much to society in the big scheme of things?
8. Do you sometimes suspect that the people who use the (products and services your company) provides might be doing stuff that you wouldn't approve of?
9. Do your company's products and services meet an already-existing need among people or will a market have to be created for these products and services?

=========

1. What are the pros and cons of "transparent" technologies?
2. Should our technologies be so "transparent/ invisible" that the user doesn't need to have any understanding of what is happening to make them work?
3. Do people become "dumber" as technologies become "smarter"?
4. Does the term, "user friendly", ever seem like an impossible dream?

=========

1. What do you find meaningful, i.e., deeply satisfying, about your work?
2. What are your greatest pleasures and satisfactions in life?
3. What are the things in life you feel most strongly connected with?
4. Do you have a side of yourself that is non-logical, not interested in technical stuff?
5. How does that side of your personality find fulfillment outside of work? On the job?
6. How does your confidence (or comfort level) with your technical work and your workplace peers compare to your confidence (or comfort level) in social settings and relationships outside work?

=========

1. How competitive would you say you are?
2. In what areas do you find yourself to be most competitive?
3. Do you compete with others or compete against yourself for more and better achievements, such as moving ahead, experiencing it all, etc.?

4. Do you sometimes find yourself in command of certain information, but unable to get it across to others?
5. Have you ever had someone else elbow in on a job you were doing and take it away from you, and get the credit for the ideas and the work?

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========

1. Talk about your women colleagues. What are some of the notable things about them?
2. Does it help/ is it important to be one of the guys? Are there advantages/ disadvantages?
3. Have you ever felt you needed to adopt "masculine" work styles as your own or adapt to the technological workplace in other ways because of your gender?
4. Talk about the inconsistencies and contradictions (both internal and external) in your life and lifestyle.

========

1. Do you find it hard to stay focused all of 8 hours on the project at hand?
2. Do you get bored, restless, frustrated?
3. How do you break up the day?
4. Are you good at asking for help?
5. Do you sometimes feel overwhelmed by having too many projects going at the same time?

========

1. You were in the Army during Vietnam years. Talk about how that sets you apart from the others your age who may be doing work similar to your own. And how does that set you apart from women who are younger?
2. Talk about how (your particular circumstance or experience/ the era in which you grew up/ your age/ whatever) sets you apart from others who may be doing work similar to your own.
3. What sets you apart from women who are younger than you in this career? Older?

========

Assorted other lines of questioning

What do the participants in the study have to say about the hierarchical organization of the workplace in terms of its contribution to the way people get along and the way work gets done? To what extent do these women in technology concern themselves with the relationships among the people at work and to what extent do they feel there is an ineptness with such concerns among the men or from management? Does the issue of concern for the interpersonal also surface with respect to the particular technology

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being researched, developed, or supported? (Example: Is it a concern that the technology be user-friendly?)

-What makes your work satisfying?
-Why did you pursue this career?
-Discuss your interest in controlling or changing the world around you.
-How closely related to the central purpose of the company is your job?
-Are you bold in making judgements and taking action on the job?
-How do you see yourself in relation to your work?

=========

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APPENDIX D

PROFILE QUESTIONNAIRE

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2672 Findley Avenue
Columbus, OH 43202
October 6, 1997

During the summer of 1995 you allowed me to interview you about your experience of being a woman in your male-dominated technical profession. Based on what I understood from those interviews, I composed a profile of you, which is enclosed.

I am now in the process of finishing my dissertation. I would like to make sure that I have not misrepresented you in this profile. I have enclosed a form for you to use to make corrections or comments about what I've written. I have also enclosed a stamped envelope for you to send it back to me. Alternatively, feel free to get back to me via email, fax, or phone. I would appreciate it greatly if you could respond within the next two weeks.

Once again, I want to thank you for the support you have given me.

Sincerely,

Linda Condron
linda.condron@osu.edu
292-7081 (fax)
688-3463 (office)
262-4356 (home)

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Profile Questionnaire

for

1. Keeping in mind that we talked over two years ago, is this profile fair in the way it summarizes what you told me about your experiences?

2. Is there any point you feel strongly should be changed in this profile? If so, feel free to write on the relevant page(s) and return them to me with this form.

3. What other comments would you like to make?

Please return this form by October 15, 1997 in the enclosed envelope.
-or-
send it by fax to Linda Condron at fax # 292-7081
-or-
call me at 262-4356 (home) or 688-3463 (work).

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APPENDIX E

AUDIO TAPE CATALOGUE

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Catalogue of Audio Tapes

Tape	Participant	Date	Location	Company
1a	Amy		phone	A
1b	Ann		phone	B
2	Ann & Amy	2/14/93	my home	
3	Gladys	1/17/95	phone	A
4a	Kathy	1/17/95	phone	A
4b	Stella	1/18/95	phone	A
5	Marie	1/23/95	phone	A
6a	Tamra	1/25/95	phone	A
6b	Helen	1/25/95	phone	A
7	Tamra	1/29/95	my home	A
8	Marie	2/1/95	her home	A
9	Marie	2/1/95	her home	A
10	Sara	2/13/95	her work	F
11	Kathy	3/8/95	my home	A
12a	Kay	6/5/95	phone	D
12b	Justine	6/8/95	phone	D
13a	Amber	6/6/95	phone	B
13b	Chris	6/7/95	phone	C
14a	Erin	6/11/95	phone	D
14b	Cecilia	6/12/95	phone	B
15	Kate	7/3/95	my home	E
16	Kate	7/3/95	my home	E
17a	Eileen	7/5/95	phone	C
17b	Dale Anthony	7/8/95	phone	B
18	Stella	7/18/95	her work	A
19a	Jane	7/18/95	phone	A
19b	Michelle	8/3/95	phone	B
20	Chris	7/19/95	her home	C
21	Jane	7/31/95	my home	A
22	Dale Anthony	8/5/95	her home	B
23	Dale Anthony	8/5/95	her home	B
24	Amber	8/7/95	her home	B
25	Amber	8/7/95	her home	B
26	Michelle	8/14/95	her work	B
27	Michelle	8/14/95	her work	B
28	Justine	9/11/95	my home	D
29	Helen	9/12/95	her home	A
30	Eileen	9/13/95	her home	C
31	Cecilia	9/18/95	her work	B
32	Kay	10/23/95	my home	D

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