Gender Differences in Professional Socialization:

A Study of Women and Men in the Computer Science Ph.D. Program at Carnegie Mellon

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Abstract

This study investigated differences in the socialization experiences of men and women who are in the process of becoming computer science Ph.D.s. In-depth interviews with women in the Ph.D. program in computer science at Carnegie Mellon revealed their experiences as a distinct minority in a male-dominated field. It was hypothesized that the absence of role models and the reduced social support structure for women would result in a less positive socialization experience than for men in the same program. A questionnaire was used to examine the experiences of men and women comparatively. No differences were found in time allocation or quality of performance between women and men, but women found their environment to be less supportive and had less positive attitudes toward the computer science profession than did men.

Chapter One

Problem Statement

There has been much talk about the small number of women entering careers in mathematics and science. Most studies find that the low numbers of women in these fields are not due to any inherent inability of women, but rather to cultural discouragement (Hornig, 1971; Feldman, 1973; Haas and Perrucci, 1984). The same phenomenon of relatively few women also occurs in computer science. In 1981 there were 9,000 employed doctoral computer scientists, and only 700 were women (National Science Foundation, 1984).

This investigation concentrates on the few women who have chosen a career in computer science, specifically those who are graduate students working towards a Ph.D. in the field. The study examines women's experiences in a top computer science department and attempts to discover how their experiences compare with those of their male counterparts.

Two important ideas guide this investigation: professional socialization and gender differences in professional socialization. Socialization is the way individuals learn roles and expectations for both themselves and also for others in society (Brim, 1966). It is through socialization that individuals come to realize not only their place in the larger social order and what is expected of them by that social order, but also what they should expect from themselves. Professional socialization is the means by which individuals become professionals. It largely takes place through advanced education. The particular context in which professional socialization occurs importantly shapes its processes and outcomes. Thus understanding the structure, values, and norms of the socialization context is important in understanding how individuals are socialized.

Professional socialization entails three processes. Individuals must learn the formal knowledge that distinguishes the profession. Individuals must practice and come to acquire the skills of the profession. Individuals must assimilate the values of the profession. Different contexts can organize these processes differently. Successful outcomes of professional socialization are an individual who knows the knowledge of the profession, can apply the skills of the profession, and has internalized the values of the profession.

This investigation has three components. The first is characterizing the context within which socialization occurs -- the structure, values, and norms of a Ph.D. granting department of computer science. The second is understanding women's perceptions of that context and their experiences within it. The third is comparing the socialization experiences of women with those of men in the same situation.

The method of investigation is primarily sociological, where much of the information is collected through interview, questionnaire, and observation. The context was characterized through historical analysis of department archives and interviews with expert informants. The experiences of women within the department were documented through an interview procedure focusing on what kind of women are in computer science, what their backgrounds are, why they chose the field, who or what were important in their decisions, and how being female has helped or hindered their success. A questionnaire procedure followed up on themes that were drawn from the interviews. The questionnaire compared socialization experiences for the women in the department to those for a similar group of men in the department.

The second theme of the current investigation is differences in the professional socialization process associated with gender. Men and women are socialized differently in our society. The cultural differences between men and women may be translated in the professional situation. Thus they may be socialized in different contexts or be treated differently in the same context.

The paper is organized into six chapters. The current chapter states the problem and outlines the approach. Chapter Two describes the theoretical underpinning of the investigation. Chapter Three describes one context in which computer science professional socialization takes place -- the Computer Science Department at Carnegie Mellon University. Chapter Four is a description of the socialization experience by a subset of the graduate student population, the women. Chapter Five compares female and male students in the department by means of a questionnaire. The final chapter is the conclusion and discussion of the investigation.

Chapter Two
Theoretical Framework

Introduction

Formally, a profession is a lifelong career which requires extensive training, has a recognized body of knowledge and literature, clear entry and exit points, a set of norms and values, and a legal governing body (Abrahamson, 1966). Using this strict definition lawyers, nurses, and doctors are professionals but academics, scientists, and managers are not. For this study, a broader interpretation of the term profession is used. A profession is a career characterized by a body of knowledge that is acquired through extensive training. A profession has skills that are practiced only by people in the profession. A profession has associated values and norms that are part of the identity shared by individual professionals. This definition thus includes managers, academics, and scientists (Vollmer and Mills, 1966; Goode, 1957; Schein, 1972).

Professional Socialization

Context

While being a professional means personal freedom, economic security, and social status, the road to becoming a professional is one marked by many trials. Individuals become professional through extensive professional training. It is in this advanced education context that socialization takes place. Each socialization context can be characterized by a particular social structure, set of values, and set of norms. In different socialization institutions these three aspects of the environment are organized differently. Social structure is the way hierarchy and rank is managed. It may be that hierarchy is emphasized and initiates are made to know their place within the social order (Dornbush, 1955). It may be the case that rank is de-emphasized and all are treated as colleagues (Oleson and Whittaker, 1966). It may be that individuals are categorized as initiates (students) or

socializers (faculty), and rank within category is ignored in order to facilitate peer unity (Becker et al., 1966). Different socialization institutions have different values. For example, the military utilizes harsh socialization procedures whereas sociology graduate school does not (Dornbush, 1955; Kleinman, 1983). There are different institutional approaches to professional socialization. In some institutions group socialization is emphasized. Students are expected to receive support primarily from peers and learn through peer interaction. Group socialization is common in programs where large classes of people are being socialized, such as in medical school and law school (Becker et al., 1966; Turrow, 1977). In some institutions individual socialization is emphasized. Students learn and are supported through a mentor relationship with an established professional, and are expected to distinguish themselves from the student group through original work (Kleinman, 1983).

Processes

Within a socialization context, becoming a professional is characterized by three processes: 1) acquiring knowledge, 2) having practical experience with the techniques, and 3) acquiring the values of the professional community (Vollmer and Mills, 1966; Abrahamson, 1966). The first two processes typically occur through advanced education and an apprenticeship in the field. In the case of computer science, as with other sciences, the steps involve graduate coursework and a research assistantship. The third socialization process entails three psychological stages that are part of attaining professional values: doubt, motivation, and commitment (Graen, 1976; Van Maanen, 1978). These stages come in the form of an initial period of reality shock and self-doubt where people spend time comparing themselves to others in the field and wondering if they themselves have made the right choice. The initial adjustment grows into motivation and a drive to succeed--a transition that involves redefining self-expectations and ideals about the profession.

Finally comes commitment to the field and an acquired identity that is consistent with that of the profession.

Outcomes

The socialization experience leads to both performance and value outcomes for individuals. The goal of professional socialization is to produce trained professionals who are both knowledgeable and skilled. These professionals should have values consistent with other similar professionals and should be committed to their chosen profession. Within the socialization process, these outcomes may be categorized as either proximal or distal. Proximal outcomes deal with immediate circumstances such as attitudes towards the socialization experience itself and behaviors within that context. Distal outcomes, which are theoretically dependent on proximal outcomes, deal with the long-term goals of the socialization process such as attitudes towards the profession and behaviors within the professional role.

Dornbusch (1955) used the military academy as an exemplar of professional socialization. Cadets were isolated from the civilian world, made to wear uniforms and crew cuts, and endured severe physical hardship. In this context they were processed *en masse* and proceeded in lock step through a series of socialization experiences. Students acquired knowledge through taking classes. They acquired skills through drills and exercises. Initial culture shock and self-doubt forced cadets to band together forming important peer-support relationships. Through this unity individuals were motivated to get through the program and to succeed as future officers. As the cadets progressed through the professional socialization process, they became military-oriented. They became knowledgeable and skilled officers who viewed themselves as colleagues distinct from the civilian population. Group solidarity was reinforced, not only among cadets of the same class year, but also within the academy and subsequently the military as a whole. They

began to understand and accept the values of the military and perhaps even rationalized the procedures of the academy as they became committed to the military profession.

Military professional socialization is an extreme example, yet many of the procedures and outcomes are similar to those taking place in educational professional socialization. Most early research focused on the socialization of health care professionals (Becker, 1966; Oleson and Whittaker, 1968). But recently lawyers and academics have also been subjects of socialization investigations (Kleinman, 1983).

Becker et al. (1966) described professional socialization in the context of medical school. Medical students learned by taking classes for their first two years; they practiced medical skills in clinic during their third and fourth years; and they acquired medical values, and modified their naive views of medicine during the entire four years. The students developed a culture in which they shared common anxieties and thus formed important peer relationships. The students felt as though they were striving to please the faculty, even though they did not necessarily agree with the faculty about what was important for them to know. Medical school reinforced a collective ideology and encouraged students to work together and learn from one another. The medical students aspired to professional doctors, but were constantly reminded that until they graduated they were students. Professional identity came through this collectiveness.

Kleinman (1983) discussed the professional socialization of sociologists. In graduate school sociology students were able to tailor the program to meet their own specific needs. Collective work was discouraged as students were expected to work in their own area of interest and to distinguish themselves from their peers by doing original research. The students partly acquired the professional identity of a "lone scholar." Sociology graduate school was different from the military academy or medical school in its emphasis of

individual rather than group professional socialization, yet in all three instances authors emphasized the importance of context and process in producing outcomes.

Individuals have different characteristics which might influence the socialization process. Thus, different individuals may have different proximal and distal outcomes within the same context. For example, publishing papers is an outcome of doing research. In order to do research, a student must interact with faculty and peers, have access to funds and equipment, spend time working on the research, and writing it. It may be the case that a group of people, based on individual characteristics, has more or less access to people and equipment, spends more or less time working, and subsequently publishes greater or fewer papers. In this study, the individual characteristic for investigation is gender.

Gender Differences

Context

Real and perceived gender differences have consequences for women in many settings, both personal and professional. Because this investigation is of professionals, the gender impact in professional settings will be emphasized. It is well documented that women have not achieved equity in professional life. Especially in traditionally male-dominated fields, such as science and engineering, the numerical inequality is especially noticeable and is an important aspect of the social structure. Tokenism, as this inequity is often referred to, is particularly a problem for women in academic and professional settings.

Tokenism takes two forms. One is tokenism of the students being socialized, i.e., an unequal sex-ratio among students. The other is tokenism among the faculty (who themselves were produced by previous professional socialization processes), i.e., an unequal sex ratio among faculty. Tokenism has two important attributes: salience and isolation (Kanter, 1977). Salience refers to the high visibility of a token based on sheer

numbers. Because the majority of people are similar and look basically the same, people in the minority receive more attention, are noticed, and are remembered more easily. This fact may lead the token to experience anxiety about performance. For women, this salience and subsequent performance pressure may lead to concerns about physical appearance, a lack of privacy, and becoming a symbolic representation of all women. Isolation occurs because tokens are different from the dominant group. They are often excluded both subtly and blatantly. The majority group may feel threatened by the perceived outsiders and subsequently emphasize the contrast between them. This contrast may also be reinforced by continual reminders. For women this may range from tolerating sexist humor to being excluded from extracurricular activities. An especially important consequence of this isolation is that women may be left out of informal networking and socialization rituals (Yoder, 1985).

Studies suggest that women in society are valued less and perceived to be less competent than men (Broverman et al., 1972; Lott, 1985). Women are perceived to be less independent, objective, and logical than men and are subsequently also perceived to be less effective than men in these areas (Broverman et al., 1972). Similarly traits that are characteristically male have higher value in society than do those that are characteristically female. The net result of these deeply ingrained beliefs is that women tend to have lower self-esteem and more negative self-concepts than men (Rosenkrantz et al. 1968). Not only do negative sex-role bias and stereotyping influence women's self perceptions, but they may also affect their ability to attain success.

Processes

If women are believed to be less competent than men, they may be taken less seriously than their male peers. Women may be excluded from informal work-related discussions and subsequently miss out on an important socialization experience. Women may have to work

harder than men in order to prove themselves to the organization (Kanter, 1977; Wiley and Eskilson, 1985; Wong, Kettlewell, and Sproule, 1985).

Same sex role models are an important part of the professional socialization process (Gilbert, Gallessich, and Evans, 1983). Not only are supportive relationships more easily formed between same sex individuals, but also career aspirations are reinforced by examples of success. For women in male-dominated fields, same sex role models may be especially needed.

For doctoral students, doing research is a way of applying knowledge, practicing skills, and also forming collegial networks through peer interaction. The ability to do research is in many cases related to the way financial aid is distributed. In 1981 women doctoral students were more likely to be supported through teaching assistantships whereas men were more likely to hold research assistantships (Hornig, 1984). This subtle difference in the socialization process may have impact on professional development as women are denied an important part of the socialization experience.

Any exaggeration of gender is especially a concern for women graduate students in computer science. The students are in a challenging and unsettling situation to begin with. They are experiencing anxiety and self-doubt because of the competitive nature of the institution. When this doubt is compounded by stereotypical beliefs and negative socialization about competence and value, the result may be detrimental to the individual. Consider also the potential bias sex stereotyping brings on top of being a minority in the situation. The psychological effects are potentially damaging. On a larger scale, negative stereotyping of women may influence who is admitted, who is taken seriously, also who is supported and advanced.

Outcomes

All of these factors, tokenism, stereotyping, and discrimination may impact the professional socialization outcomes. While women perform as well as men in academic situations they may not have the same career opportunities as men do. Despite affirmative action, women Ph.D.'s are significantly underrepresented in industry. Women in academia are less likely than men to be hired for tenure track positions. Women also earn significantly less than men with the same degree and amount of experience (Hornig, 1984).

Studies outside the domain of computer science have show that men and women have different attitudes towards their careers. While men may be motivated by monetary gains, women seek expressive outlets (Cartwright, 1972). Similarly men are likely to wholly identify with their professions and women are not. Women may be less committed to their careers due to the culture in which they were raised (Stein and Bailey, 1973). Professional women may experience role-conflict when decisions must be made about raising a family (Farmer, 1987).

Based on what is known about the professional socialization experience and women in professional settings, the process of becoming a Ph.D. computer scientist may look different for women than for men. The context may be different, with a social structure, norms, and values less supportive for women than for men. Their learning experiences may differ. And as a consequence of these differences, women may be less fully socialized to the profession than are men.

Chapter Three

The Department and the Doctoral Program: The Socialization Context.

Introduction

Different organizational contexts organize socialization processes differently and thereby produce different socialization outcomes (Van Maanen, 1978). Thus professional socialization can not be understood without understanding its organizational context. Context, as discussed in Chapter Two, can be characterized by three elements: social structure, values, and norms. Social structure is the relatively stable pattern of roles, specialties, and interactions. The current social structure can be understood in part through tracing its historical development. Values are the underlying principles governing behavior and the goals to which one aspires. Values can be understood in part through understanding assumptions people share. Norms are the requirements and informal expectations for behavior. Norms can be understood in part through knowing what requirements students are expected to meet and how they spend their time.

Historical Background and Current Social Structure

In 1965 Carnegie Institute of Technology was awarded a $5,000,000 grant from the Richard King Mellon Foundation to create a Department of Computer Science. The department was formed by merging the Systems and Communications Science Program, an ARPA funded research group, and the University Computation Center. The department granted its first two Ph.D.'s in 1967. In 1970 Computer Science broke away from the Computation Center and became a separate entity. The department was no longer responsible for computing needs of the entire campus and subsequently focused on obtaining equipment and personnel for itself (Zubrow, 1984).

In the years following its formation, the department grew substantially. The number of faculty has demonstrated continuous growth. In 1966 there were 10 faculty members, all men. The first female faculty member, a graduate of the department, was hired in 1971. That year there were a total of twenty full time faculty members. Between the years 1970 and 1981 the number of faculty almost tripled. By 1974 the proportion of female faculty members had reached a high of twelve percent. In 1986 there were only two female faculty members (See Table 3.1).

Table 3.1
Teaching and Research Faculty Composition over Time by Gender

Year	M	F	%Female	Total	Year	M	F	%Female	Total
1966	10	0	0	10	1976	26	2	7	28
1967	14	0	0	14	1977	32	2	6	34
1968	16	0	0	16	1978	37	3	8	40
1969	22	0	0	22	1979	43	3	6	46
1970	16	0	0	16	1980	32	3	8	35
1971	19	1	5	20	1081	44	3	6	47
1972	27	1	4	28	1982	42	2	5	44
1973	26	2	7	28	1983	53	2	4	55
1974	22	3	12	25	1984	57	2	3	59
1975	26	3	10	29	1985	54	2	4	56
					1986	77	2	3	79

(Data source: *Computer Science Research Review*, an annual publication of the Carnegie Mellon University Computer Science Department for years 1966 through 1980. Carnegie Mellon University Faculty Directory for years 1981-1986)

Although the university formally recognizes only professors, assistant professors, and associate professors as faculty members, the department makes no such distinctions and considers both teaching staff (professor, associate professor, assistant professor), and research staff (senior research computer scientist, principal research computer scientist,

research computer scientist, research associate) to be faculty. Both groups are eligible to advise graduate students.

In 1986-87 academic year, there were 79 individuals able to advise graduate students, 44 were teaching staff and 35 were research staff (see Table 3.2). One of the female faculty members was an assistant professor and the other, a recent graduate, was a research associate.

Table 3.2
Individuals Eligible to Advise Graduate Students in the Computer Science Department

Teaching Staff	M	F	Research Staff	M	F
Professor	16	0	Principal Research Computer Scientist	3	0
Associate Professor	11	0	Senior Research Computer Scientist	5	0
Assistant Professor	16	1	Research Computer Scientist	12	0
			Research Associate	14	1

(Data source: Carnegie Mellon University Computer Science Department, Listing of Teaching and Research Staff Payroll Titles.)

The number of graduate students has also been increasing. In 1965 there were 24 graduate students enrolled. Ten years later, in 1975 there were three times as many and the enrollment has continued to increase. In this first decade of the computer science department, the average enrollment of female students was 6.4%. Since 1975 that average percent has increased to 9.4%. In 1985, the proportion of women to men was the closest, with 17% of the graduate students enrolled being female. This was the only year in the history of the department that the total percentage of women enrolled was greater than 15% (see Table 3.3).

Table 3.3
Student Enrollment Over Time by Gender

Year	M	F	%Female	Total	Year	M	F	%Female	Total
1966	49	2	4	51	1976	80	3	4	83
1967	42	2	5	44	1977	84	4	5	88
1968	53	4	4	57	1978	81	3	4	84
1969	38	5	12	43	1979	77	5	6	82
1970	56	5	8	61	1980	73	6	8	79
1971	60	3	5	63	1981	87	10	10	97
1972	71	5	7	76	1982	101	12	11	113
1973	71	4	5	75	1983	104	15	13	119
1974	61	3	5	64	1984	99	18	15	117
1975	76	3	4	79	1985	104	21	17	125
					1986	122	18	13	140

(Data sources: *Computer Science Research Review*, an annual publication of the Carnegie Mellon University Computer Science Department for years 1966-1980. Carnegie Mellon Registrar records of Computer Science Department enrollment by gender for years 1981-1986.)

Entering classes in the past ten years have shown increasing numbers of female students entering the program. The average proportion of women leaving the program is not significantly different from the average proportion of men (see Table 3.4). For the eleven year period from 1975 to 1985 the average proportion of women who left without a degree was 48%; the average proportion of men was 25%. For the more recent five year period from 1981 to 1985 the average proportion of women who left without a degree was 21%; the average proportion of men was 14%.

Table 3.4
Attrition Rates by Gender for Entering Cohorts

	Males			Females		
Year	#M	#M left	%M left	#F	#F left	%F left
1975	22	9	41	1	0	0
1976	20	6	30	1	1	100
1977	15	4	27	1	1	100
1978	10	3	30	1	1	100
1979	17	7	41	1	1	100
1980	17	6	35	2	0	0
1981	19	3	15	6	3	50
1982	24	5	21	3	1	33
1983	23	5	22	5	1	20
1984	16	1	6	3	0	0
1985	21	1	5	3	0	0
Mean	19	4	25	2	1	48

(Data source: Carnegie Mellon University Computer Science Department Student status by year of entrance records.)

The social structure of the department is strongly influenced by the structure of the university. Universities in general tend to appear decentralized when compared to other organizations. Carnegie Mellon is an extreme example of such decentralization. Decisions are made on the departmental level which allows the department to be autonomous. For instance, the department does not want to offer an undergraduate major and has the autonomy to not offer one despite strong student demand. This decision allows the department to save tremendously on people and facilities resources. It also heightens the research emphasis of the department.

There are few subunit boundaries within the department. Computer Science tends to be an organic entity. Resources and people are fairly distributed across the department and a principle of student democracy governs departmental workings. Important decisions about

admissions, qualifiers, facilities, space, and budget are made in committees comprised of both faculty and students.

There are several factors involved in the structural decisions. First, Computer Science began as an interdisciplinary program. In fact, the field of computer science itself is to a large extent interdisciplinary. The original department brought together people from math, psychology, industrial administration, and electrical engineering, a synthesis which is reflected in the current loose boundaries within the department. The Computer Science Department has embraced prominent scholars from other departments on campus, currently granting joint appointments in Computer Science to 10 faculty members (Listing of Teaching and Research Staff Payroll Titles).

Second, while there is great flexibility within the department, the boundaries between the department and the larger university are quite strong. The Computer Science Department almost totally disassociates itself from the larger university. As noted above, there is no undergraduate computer science major. The department had little participation in the major campus computing experiment, Andrew, a campus-wide network of workstations that is jointly sponsored by IBM. In fact the boundaries of the department with respect to campus have become even more clearly defined. The department recently seceded from the Mellon College of Science, under which it was previously administered, and became its own college.

A third factor influencing the relaxed organizational structure of the department has to do with funding. Although the department is situated within the university, Computer Science acquires its own resources through sponsored research. Originally the money was awarded to provide programmatic support. Thus, early funding was always ample and unpoliticized, which contributed to flexible internal organizational boundaries. This

practice set precedents for resource allocation in the department and also allowed graduate students to be supported out of general funds, ones not tied to specific projects. This communal practice is intended to produce a more coherent organization, less internal competition, and also less stress. Students are free to change projects and advisors without fear of losing financial support.

> Most students are supported by the Computer Science Department as research assistants. This support comes directly from the department, and is not linked directly with your advisor or current research work. Department stipends cover all tuition and University fees (except health insurance and parking permits) plus a take-home paycheck... (Computer Science Department, 1985).

Four major areas of computer science are represented in the department. Artificial intelligence attracts the most people, with programming systems running a close second. Computer systems is third, and is closely affiliated with the Electrical and Computer Engineering department. Four current computer systems faculty members hold joint Computer Science, Electrical and Computer Engineering appointments. Theory has the fewest faculty and students (see Table 3.5).

Table 3.5
Areas of Concentration for Faculty and Students in the Computer Science Department

	Artificial Intelligence		Programming Systems		Computer Systems		Theory	
	M	F	M	F	M	F	M	F
Teaching Staff	10	1	8	0	13	0	11	0
Research Staff	15	0	10	0	9	0	1	0
Graduate Students	60	10	37	6	15	2	8	0

As of fall 1986, there were 139 graduate students enrolled in the Computer Science Department, all working towards Ph.D.s. Of the eighteen female students currently in the Ph.D. program, ten were concentrating in artificial intelligence, six in programming systems, and two in computer systems.

Culture and Values

Three vital aspects of the computer science. culture underlie many of the assumptions people share. The first is the emphasis placed on quality scientific research. One rationalization for this emphasis has to do with funding, yet even this does not explain the drive and passion exhibited by scientists doing research. Original research demands total immersion in the task at hand -- an almost selfless devotion to the field. Allen Newell, a prominent figure in the department is quoted by a doctoral student as reporting "My interest is computer science, and I gave up all my other interests for it" (Pearson, 1986). There are values that both motivate and stem from this mode of work including a need for individual autonomy and flexibility and more interestingly, a need to discover. For many scientists, an important motive for getting a Ph.D. is acquiring the credibility to design and run research projects that interest them. Flexibility for scientific research has to do not only with schedules, but also problem definitions. Research scientists are working to satisfy their desire for knowledge. People in computer science are very proud of their position.

> Our department offers students an unparalleled opportunity to learn, to participate actively in state-of-the-art research, and to be members of an exciting intellectual community. Nearly every branch of computer science is represented, and there is a strong sense of friendly cooperation, collaboration, and interplay among the different branches (Computer Science Department, 1985).

The department has historically been better known than the university at large. It is known as one of the top three computer science departments in the world, and no other department on campus can claim comparable stature (Science Magazine, 1982; U.C.L.A., 1979). The

department exists distinct from the university at large. Computer Science people are simply tenants of a university building rather than an integral part of campus life because the department is a functional unit that not only provides a place for work, but also a complete social environment.

The second emphasis is "reasonability." It is embodied in a departmental policy, the "reasonable person principle," that states, "individuals and individual circumstances are more important than arbitrary rules" (W.A. Wolfe, 1978). This policy extends itself to be an important aspect of the culture of the department. Not only are problems handled in a reasonable manner, but people in the department are expected to behave in a reasonable way, reasonable requests are to be granted, and everyone is reasonably satisfied.

A third aspect of computer science culture is a great sense of community. The values of democracy and equality are strongly emphasized. Everyone is on a first-name basis and the environment is extremely relaxed. The dress of the department is casual and on any given day there are people spending time reading the newspaper, reading bulletin boards and mail, or just talking in the lounge and in offices.

> There is a Computer Science Department team entered in most events in the University's intramural games. There are pickup games of soccer, frisbee, basketball, football, softball, and volleyball. There is always something happening in the lounge - be it a game of darts or chess, someone cooking lunch or reading the Times, or an argument about biochemistry (Computer Science Department, 1985).

Nevertheless, there is unspoken acknowledgement of rank based on prominence within the field. An obvious testimony occurred in an introductory meeting for first year students. Veterans in the program warned new students that they had to get used to the fact that "they were now dealing with people they had once only read about" (Dill, 1986).

The computer science community values openness and cooperation. The department is reputed to have an extremely friendly environment and members of the community pride themselves on this fact. New students are welcomed into the computer science "family." Upon acceptance, students are sent "The Carnegie Mellon University Computer Science Department Guide to Living in Pittsburgh," a book is written by students and published in the department.

> This guide is written for people like ourselves: graduate students who will be living in Pittsburgh for a few years, then moving on... We wrote this guide from our own experiences. It is very personal and excessively opinionated. We aren't trying to tell you about all of the restaurants in Pittsburgh, just the ones that we like. We don't tell you about every hardware store or bar, but only the ones that we like and frequent. If you want a complete list, you can turn to the Yellow Pages (Sansom and Hodgins,1985, p.iii).

It is a friendly description of what to expect from the city that also gives students a sense of what to expect from the department. The new student is guided through the traumas of being in a new city with the advice and assistance of what seems to be the entire department.

> Your first step in coming to Pittsburgh will probably be to find a place to live. Many grad students who come here have never lived in their own apartment before, and may find the task of finding a place to live to be very difficult. Fear not! We've lived here for several years, and can help you out quite a bit (Sansom and Hodgins, 1985, p.13).

The book is filled with "we like," "we suggest, " "our favorite." The concern for the computer science community is evident and the person reading the guide gets a sense of what people from the department like and value in life and what the new recruit is expected to like and value.

Norms and Requirements

Professional education attempts to balance theoretical knowledge and practical experience. In most places this balance is achieved by having students spend the first half of their education in a classroom and then the second half in clinical or practical work. In the Computer Science Department it is quite different. As A. Nico Habermann, the head of the department, states, "The department takes both research and education very seriously" (Computer Science Department, 1985). As a result the two are tackled almost simultaneously. There are no required courses, and students are expected from the beginning to be thinking about research.

> Our education of these students is based on two philosophies: adaptation of the program to reflect individual needs, and early and total involvement in research (W.A. Wolfe, 1978)

Students must meet five formal requirements in order to graduate (Computer Science Department, 1985). The requirements are: passing core qualifying examinations covering theory, programming systems, computer systems, and artificial intelligence -- the major areas of computer science at Carnegie Mellon; a research apprenticeship; teaching for at least one semester; completing an area qualifier, which is an individual research project; and completing a thesis describing original research in computer science. The program, however, prides itself on being very flexible. How and when these requirements are met differs among students. This can partly be viewed as a result of the department's growing in a time of radical ideas about education.

> What the graduate students learns, not what he is taught, is the essential issue. Extreme variation in graduate students exist with respect to the amount of structuring they need and/or want. But fundamentally, a graduate student should be in control of his own education processes, for no one else can be (Perlis and Newell, 1969).

It may also be a result of the general prosperity the department has enjoyed. Students are not rushed through the program and it is not unusual to find graduate students still around after seven or eight years although the typical student is expected to finish between four and six years (Computer Science Department, 1985).

Graduate student progress in the Computer Science Department is evaluated once every semester. The entire faculty, in an all-day meeting, evaluates each student individually. Progress is not measured primarily by grades in courses or performance on exams. This evaluation process is known by both students and faculty as Black Friday. The results are communicated to each student in the form of Black Friday letters, which in the best possible case state, "You are making satisfactory progress." In some instances the letter itemizes tasks that must be accomplished in the next semester. This letter serves as a warning. In the worst situation the letter is a notification that the student must leave the program, but that is only after at least one prior warning letter. Many factors weigh in the Black Friday decisions including: courses, exams, research projects, teaching load, and committee membership.

There is an assumption that all of the students in the program are qualified to be there. This assumption is evidenced by the flexibility of the program and the evaluation process. The assumption extends itself to the department's wanting to graduate all of its students. The program is structured to help students through. Courses are offered, not to eliminate students, but rather to prepare them with the appropriate knowledge for the qualifying exams.

The description of the Computer Science Department thus far does not clearly depict the actual day to day life of people in the department. Four social processes: the Immigration Course, electronic mail and bulletin boards, "T.G.'s" (lounge parties), and the Liebermann Queue, demonstrate the interplay of values and norms in the way things happen on a day-to-day basis in the Computer Science Department.

First year students are eased into the department during the Immigration Course (I.C.), four hectic weeks in the beginning of the fall semester. During these weeks students are introduced to faculty, staff, and other students. They are given a chance to familiarize themselves with the computers and the department in general. Students are given the chance to hear experts speak about the different areas of computer science and describe current research. There are question and answer session as well as talks on how the department works and how to survive as a graduate student. There are lectures and seminars as well as parties and receptions. Consonant with the egalitarian spirit of the department, faculty and advanced graduate students do most of the planning and work for the I.C collaboratively.

Much of the work-related exchange in the department takes place informally. The values of community and equality allow people in the department to freely comment, criticize, and contribute to other projects. Seminars presenting current research are scheduled weekly. An important mode of interaction, besides informal gathering, is over the computer network. A huge amount of information is conveyed via electronic mail or electronic bulletin boards. There are 37 different electronic bulletin boards for the Computer Science Department alone. Seminar announcements, items for sale, apartments for rent and requests for books or papers are all commonly posted on these bulletin boards. Electronic mail serves as a surrogate telephone, making short conversations very convenient. Even invitations to parties are distributed over the computer mail network.

The department frequently has T.Gs (lounge parties) on Fridays afternoons. The gatherings are student organized and open to the entire community. T.G.'s are sponsored by an organization known as Dec5[1], whose sources of money include departmental Coke

[1]Rumoured to be named for its founding date of December 5.

machines and funds from the campus Graduate Student Organization. Over 600 people are on the electronic invitation list for T.G.'s and two to three hundred students faculty and staff regularly show up (Novak, 1987).

The Liebermann Queue is a student-managed mechanism for accomplishing tasks that benefit the entire department, but that are no one person's responsibility. Things like cleaning the lounge, recycling paper, and grading for undergraduate computer science courses are considered appropriate for the Liebermann Queue. While participation in the Queue is completely voluntary, almost everyone does. There are a few "deadbeats," but for the most part all of the graduate students are committed to the idea and put in their time. Everyone's name is put on a big list that is sorted by the number of credits one has earned.

> Every job is worth a number of points, based on the amount of time and responsibility that go with it. The queue is arranged so that students with few points will migrate to the head and thus be eligible for job assignments. The idea is to volunteer for a job you like (hence, getting points and moving from the head of the queue) before you get assigned to one you don't like (Liebermann, 1971)[2].

As jobs come up openings are posted on the general electronic bulletin board and the queue manager asks for volunteers. If there are no volunteers, then people from the front of the queue are sent electronic mail as friendly coercion. People with a high number of credits who frequently volunteer are at the back of the queue (Goldberg, 1987).

Conclusion

In general, the Carnegie Mellon Computer Science Department is successful and growing. The department rests on a solid reputation, has substantial funds, equipment, and talented

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[2]Although the spelling is different, the queue was supposedly invented by and named for a graduate student, Liebermann, in the early 70's.

people. These resources allow the Computer Science Department to provide a supportive socialization environment for aspiring Ph.D.'s. Perhaps more important to the supportive environment are the shared values of flexibility, democracy, equality, and reasonableness. Within the context of the department, the socialization experience is highly individualistic for each student.

Unfortunately there are mixed blessings for women in the department. Although there is great talent in the department, there are very few women. There are few female faculty role models and few female graduate students; thus, there is less of a same-sex support structure for women. The generally supportive environment may compensate for this shortcoming, but the female students may still have a more difficult time than the men. The female students may not perceive the environment to be supportive despite the prevalent rhetoric. And while all students are expected to be self-motivated, the women may have to be more so, due to their minority status.

Chapter Four

Women in the Computer Science Department

Introduction

Chapter Three was a neutral description of the context in which professional socialization occurs. While the numbers of women in the department are extremely low, there do not seem to be indications of discriminatory behavior. There simply do not seem to be many women interested in becoming computer science Ph.D.'s, which accounts for the low numbers of female students and faculty. However, this neutral description does not completely represent the context in which socialization takes place.

The socialization context is more accurately represented by student perceptions of the context. Supportiveness, harshness, individualism, democracy, flexibility, and other attributes of the socialization environment are all subjective characteristics. Therefore, the knowledge, skills, and values that students acquire are influenced by the way they perceive the social structure, the values, and the requirements. Thus for women, the context is equitable only if they perceive it to be so.

The best method for understanding student perspective would be to experience the same context. Since this is not always possible, the next best alternative is to have students describe the experience in their own words. In this way, the outsider can know what students feel is important, what they value and like, and also what they find to be trying and uncomfortable. In this investigation the free format interview methodology was used to discover how women decided to enter the field of computer science, how they perceived the departmental context, what their experiences had been, and what they aspired to when they graduated.

Procedure

In the first week of the fall semester of 1986, all eighteen of the female graduate students were mailed a letter describing my study and inviting them to be interviewed (see Appendix 4.1). Seventeen out of eighteen women agreed to participate; the eighteenth woman took a temporary leave of absence during the course of the study. Interviews were arranged either by phone or electronic mail. Interviews took place in student offices, lounges, even outside on the grass, and on average lasted approximately one and a half hours. The interviews were conducted informally using an interview guide (see Appendix 4.2), and took the form of unstructured conversations. Every interview was taped and later transcribed.

In all of the conversations the women discussed their backgrounds, and early influences on their decisions to go into computer science. They talked about their undergraduate experiences and their decision to go to graduate school. The conversations centered on what they were working on in the Computer Science Ph.D. program, and their experiences and feelings as graduate students at Carnegie Mellon. In some instances they spoke of specific advantages or disadvantages to being a woman in such a male-dominated field. Finally, some of the women discussed scenarios they imagined after graduation.

Background and the Route to Computer Science

The women in the Computer Science Ph.D. program described themselves as atypical from early on in their academic careers. In this sense their descriptions resembled those found in other studies of women in science and mathematics (Gornick, 1983; Rossiter, 1982; Tangri, 1972). They talked about being at the top of their class all through school and always liking math and science, entering math competitions and science fairs. One woman spoke of a "mystical" experience in junior high math where "some intuition was born that

let me know there was something behind those symbols. That it was a world that exists only in your mind (A.L.)."[1]

High achieving women usually come from higher income, educated families who encourage achievement (Stein and Bailey, 1973; Cartwright, 1972). Not surprisingly the five women who had academic or scientific parents reported being significantly influenced by them.

> If you would ask [my sister and me] why we went into science, it would be be because we were inspired by my father. He's a research scientist in industry... So he has a few patents and that sort of thing. And it sounds really cool. So ever since my sister and I were growing up, we just always had the feeling that research science is the only profession -- the only thing I've ever considered doing (R.O.).

While all of the women talked about being interested in science and math, computer science was not an obvious choice for most. Only five of seventeen went to college knowing they wanted to pursue computer science as a major. Two studied related fields: electrical engineering and math. Nine of the women planned to major in such diverse fields as physics, chemistry, and even French. By chance, usually as a science requirement, they took a computer science course and ended up loving it. They then switched to computer science. Only one woman had no undergraduate experience with computers -- but she had a computer science masters degree.

Eight of the seventeen women held jobs after graduating from college and before returning to graduate school. All were motivated to return to school when they realized the freedom a Ph.D. granted.

> I realized that if I ever wanted to have control of the kind of work I did... if I wasn't going to be just somebody else's drone, I had to have that piece of paper (D.E.).

Perceptions of the Socialization Context

Social Structure

Everyone spoke positively about the sense of community within the department, yet consonant with the literature on tokenism (Kanter, 1977; Yoder, 1985) these remarks were sometimes coupled with talk of isolation and loneliness.

> The women don't seem to band together in the way the men do. The men have the cliques and networks and there is more cameraderie than there is amongst the women... I feel a little more alone than I think a lot of women I know. Just because there is not as much of a support structure (I.T.).

This lifestyle, the life of a computer science graduate student, remains best suited to bachelors. There are no accommodations for family and other time constraints. To be part of the "club" requires a certain amount of effort, meaning time spent on campus, and time spent in social outings that are usually spontaneous.

> And it wasn't until recently that [the men] would think to invite me to some of these things that they would quickly invite each other to... like moving parties and things like that. I don't necessarily have the strong back that they do, but they become important social functions (I.T.).

Interaction with peers and faculty is an important attribute of the professional socialization process (Kleinman, 1983). Yet talking about quality interaction with peers and faculty was not common to the conversations with the female students. Presumably advisors or peers play an important role in the way students perceived their work, yet only three women mentioned their advisors at all. One woman saw her advisor as an important role model.

> [My advisor] is very world renowned in academic circles and he does work in more than one area of computer science. He's also a principal in his own company, so he does more than academics. So I guess as much as anything he may be a role model (E.L.)

And when the women mentioned peers, it was more in terms of social than work settings.

Values

All of the women in the program commented on the friendliness of the Computer Science community. In general, the Computer Science Department was talked about as an open, flexible, relaxed place to be. These characteristics seemed to be important in determining how satisfied students were in the program, and also why students came to Carnegie Mellon in the first place.

> There are some unique and good properties about Carnegie Mellon that would have made me come here even if I had gotten into MIT or Stanford, which would have been the other obvious choices. I think I would have come here regardless. Carnegie Mellon does some things really right (T.P.).

The women all said they were most attracted to Carnegie Mellon because of the friendly atmosphere, despite the weather and the bad reputation of the city of Pittsburgh.

> Carnegie Mellon was my first choice because they had the best facilities and because I think that it is a good school and also because there are nice people here. I am the sort of person who depends very much on the social environment. Not as much on the rain or on the prettiness of the city, but how nice the people are. So Carnegie Mellon was a good place to come to (L.R.).

The university was viewed as a safer environment than working in the "real world." Academia was described by the women as softer than industry.

> School is much different. It is a very forgiving environment, I think. This place in particular. I feel there is room to make mistakes, maybe too much room. But you don't get stomped on and you don't get pushed around and you are given a lot of support (A.L.).

Eleven of the women interviewed cited Carnegie Mellon's reputation in computer science as being an important factor.

> I heard that Carnegie was supposed to be one of the best programs. So I looked at all of them. I didn't like the way Stanford felt. The people didn't seem very happy there -- the students didn't seem happy (D.E.).

Norms and Requirements

Eight of the women mentioned the flexibility of the program was an important factor in their decision to come to Carnegie Mellon.

> I wanted to come [to Carnegie Mellon] because this place is a lot more flexible and research oriented -- the graduate school is. There are a lot less requirements and a lot less rigidity. And they give us a lot more freedom. It is just a lot nicer environment (C.N.).

Although there is flexibility, the female students felt pressure to perform within their computer science graduate student life.

> There is pressure that is mostly self-imposed -- that this is a great department and people here are doing really great things. And you feel really compelled that your work should be equally as good as these other people (E.L.).

Peers and advisors apparently were also sources of motivation and pressure.

> I don't feel any need to push myself as hard as I can. What I mean by pushing myself as hard as I can, I mean working 10 hour days six or seven days a week. I don't feel any need to do that as long as I'm not getting pressure from my advisor or something like that (O.C.).

Advisors influenced the mode of working adopted by the student. Two women spoke of how their advisor influenced the way the proceeded in their work.

> I've only done individual projects -- just my advisor and I. Mainly me. Lately what happens is I do the work, and he thinks up new things (R.O.).

> I started working on [my thesis proposal] last semester and then my advisor went away for six months. So that really slowed everything down. I really felt like I needed to be talking to him, and so I didn't get much done... except trying to get ideas together (O.C.).

Although the women spoke of feeling left out of the male-oriented social environment, no one spoke of obvious disadvantages in the socialization context. No one felt blatantly discriminated against, although over half discussed subtle gender distinctions.

> I haven't felt like there has been any discrimination. Sometimes there are little things that people do. Certain people can act a little sexist. But usually I feel like I separate that from the working relationship. As far as my work goes, I haven't experienced anything where people are sort of taking me less seriously (N.Y.).
>
> I don't feel like I have to work harder because I'm a woman. I've never had to fight for things like that. I've had fights, struggles on personal one to one levels, but I never had an experience where I got screwed by an organization because of my sex (A.L.).

Surprisingly, four of the women interviewed believed that being female was an advantage when it came to admissions decisions.

> The fact that I am a woman in the department might have given me advantages as far as getting in. And I have no idea what they do about that, if there is any kind of quota or anything. I think here and other places there is probably some sort of informal thing. Although, who knows (N.Y.).

One carried it further and stated that she might not have been accepted to the program had she been male.

> I was shocked that I was accepted here. I really don't know how much of it had to do with being a woman. It wouldn't surprise me if that was a big advantage. It wouldn't surprise me that [given] a man with the same record they would turn him down. I just don't know (A.L.).

The women in the Computer Science Department appeared to be relatively satisfied with their environment -- otherwise they probably wouldn't still be there. On the other hand,

Page 34 missing from the original document.

> It's hard to adjust to doing mostly research because as an undergrad you don't have a lot of working on your own. I have a hard time with that sometimes. With having all this freedom and no specific deadlines (N.Y.).

Although these women have chosen to be professional computer scientists, they emphasized maintaining other interests. Interestingly this value of wanting to 'do more than academics' surfaced as the women talked about their work in computer science -- especially those who were concentrating in artificial intelligence. Eight of the ten women in AI said that one reason that they liked their work so much was that it incorporated so many different things.

> I tend to be interested in all sorts of things, not just science. AI involves lots of philosophy, psychology, cognitive science and linguistics. So, AI, the field of AI, has a mixture of all of these different fields and concerns. And that really intrigued me (B.D.).

Computers were talked about as a mere tool. The actual work of research is solving problems and computers are merely the method.

> Actually artificial intelligence is an area that overlaps many areas of research, like psychology, physiology, many languages, philosophy, math, and computer science in order to implement the things. It is much more than just dealing with the computer. You use the computer as a tool. So that's basically why I started computer science in the first place. Because I liked the idea of thinking about humans and about intellectual capabilities (H.I.).

Acquiring Values

The women in general seemed to identify with the professional values their faculty role models exhibit. Autonomy was an important career value. Of the nine women who came straight to school, most were similarly motivated as they felt trapped by the low level part-time and summer jobs they had held.

> It was reasonably clear [that I would go to graduate school] because all the summer jobs that I have ever had... it wasn't that I hated them but I always worked in places as a summer student where everybody else

> was a Ph.D. and I loved them. Yeah. So it was more like I wanted the kind of job these people have (U.W.).

Another aspect of this autonomy was flexibility -- in both the kinds of problems to solve and also the manner of working.

> A lot of people who are in computer science are the kind of people that want flexibility in their hours -- they expect it. And computer science is the kind of field where that's pretty easy to accommodate (C.N.).

Career Aspirations

As expected, respondents' age was related to the salience of careers. The ten women who have been in the program four or more years were thinking more about life after graduate school, while some of the younger women were not even sure they'll finish the degree.

> It's still a big question mark. Even now I don't know. It doesn't seem a foregone conclusion that I'm going to do it. I am doing research now, but the idea of doing a thesis seems like a big thing to do. Sometimes if I am feeling overwhelmed, I could say forget it (N.Y.).

Of those who spoke about careers, only two women, both of whom had husbands who worked at the university, wanted to stay at Carnegie Mellon. In contrast, three women specifically said they would not like to be at a place like Carnegie Mellon because the pressure and the politics were too intense. Most of the women thinking about the future expected to work in industry rather than academia.

> I sincerely doubt that I will stay in academia. When I first came here I thought I would, but I've seen too much of faculty politics and faculty fighting and back-biting. There's some politicking in industry, but it wasn't my experience that it was as cutthroat as it was here... You have empire builders more than you do in industry (T.P.).

Others specifically did not want to be involved in academia because they did not like teaching.

> I basically want to be left alone to do research. I don't really want to teach. In my experience, the only college kids I taught were completely unmotivated and completely ungratifying. It's not that I'm a bad teacher. I think that I'm a fairly good teacher, but I find it to be a lot of work for very little return. And you don't get anywhere in your own work. It saps your strength. I'm very selfish. I want to do what I want to do (D.E.).

By contrast, at least two woman viewed the teaching interaction as important.

> Computer science is technical, it's not dealing with people. That sort of bothers me... I sort of would like a more people oriented thing. As an undergrad I did a lot of teaching because they were really short on teaching assistants. I really liked that a lot (N.Y.).
>
> I wish I had more personal responsibility in my professional life. You don't have that when you're hacking. After a while, it just gets routine. If I were teaching, I think I would enjoy that -- just interacting with people and the problems of people (K.R.).

Talk about future goals revealed two conflicting values: eminence in the field and a well-rounded life. People seemed to believe that success in science requires absolute devotion to its pursuit. Although the women admired faculty members who had devoted their life to the science, no one wanted to fashion her life in that model.

> There exist people, in our department, who fully believe... and it's not computer science, it's science in general, who believe that to be a great scientist you have to work forty hours a day at it and you can't have anything else in your life... There's all these considerations about what you want your life to mean. If it needs to mean nothing else than being a great scientist and you are the kind of personality that can work those long hours and be productive, then that's probably not a bad thing to do. But I don't think those assumptions hold for me (E.L.).

While the women valued having a successful career, they also valued maintaining outside interests, which often included having a family. This conflict is characteristic of the role conflict experienced by professional women (Farmer, 1987).

> Just seeing the way the faculty works, talking to different faculty members. Every year they work here they get more and more

> commitments and they're working more and more hours. And I sort of feel like, gosh, what kind of family life do they have (N.Y.).

Even when the role conflict was not specifically gender oriented, women seem to value different things in life. They subsequently saw the future as a choice between happiness and success.

> I don't want to eat, breathe, and sleep computer science. Yes, it's what I want to do as my work, but there are plenty of other things in the world (D.E.).

Discussion

Consonant with the literature women found few same sex role models and experienced a sense of isolation in their work (Kanter, 1977; Yoder, 1985) The work in graduate school was hard, and the socialization experience was unsettling (Becker et al., 1966; Kleinman, 1983; Schein, 1972). Unlike other studies of women in science (Gornick, 1983; Hornig, 1984), the women in the Carnegie Mellon Computer Science Department did not feel discriminated against, nor did they perceive their experience to be very different from that of the men in the program. Although the women in this study found their environment to be generally supportive, they did appear to have some ambivalence toward the professional values demonstrated by their faculty role models. This ambivalence may be because most of the role models are men. It may be because women are culturally socialized against career commitment. It may be due to a shortcoming in the professional socialization process.

The next chapter will compare the women with a similar group of men to gain more insight into whether the experience of becoming a computer scientist is the same for women and men.

Chapter Five
Comparing Women and Men

Introduction

Chapter Two identified important elements of the socialization process, Chapter Three described the socialization context, and Chapter Four described how the women in the Computer Science Department view their socialization context and experiences. In this chapter I explicitly compare female and male students on four issues identified as important in Chapters Two, Three, and Four. They are two elements of the socialization context -- social structure and norms -- and two elements of socialization outcomes -- performance (which combines knowledge and skills) and values.

I hypothesize that women will perceive their social structure to be less supportive than men. This is because they have fewer same-sex role models and peers than male students do. I hypothesize that there will be no difference in normative behaviors such as how students spend their time. This is because the formal requirements for the program are the same for all students. I hypothesize that there will be no difference in performance; therefore, there will be no difference in the knowledge and skills acquired. This is because I assume students are equally intelligent, equally able to do the required work, and have equally sufficient access to research opportunities. I hypothesize that women will display less positive attitudes towards the profession of computer science than will men. This may be because of the less supportive socialization environment, because there are few women in the larger professional environment, and also because of societal expectations for women.

To investigate these hypotheses I conducted a study of female and male Computer Science graduate students in January, 1987.

Sources of Data

There were two sources of data for this study: student records kept by the department and a questionnaire. The departmental records included information about advisors and information about student performance i.e., grades on qualifying examinations, semesters spent teaching, and number of technical reports published. The questionnaire examined perceptions of social structure, normative behaviors, performance, and professional values.

Subjects

Data obtained from the department were available for all of the students currently in the department (n=139). The questionnaire was administered to a stratified matched sample of students. All eighteen women were sampled. The men in the sample were chosen to match the eighteen women in the program with respect to area of concentration and also year in the program. This resulted in a total sample of eighteen women and eighteen men. Twenty-two of these students were concentrating in artificial intelligence, ten in programming systems, and four in computer systems. There were two initiates, fourteen novices, and twenty veterans (see Table 5.1). An additional random sample of eighteen men was sent the questionnaire to explore whether the matched men were different from men in general in the Department.

Table 5.1.
Description of Men and Women in the Sample

Tenure / Area	Initiate (1st year)	Novice (2nd/3rd year)	Veteran (4th + year)	Total
Artificial Intelligence	2	10	10	22
Programming Systems	0	2	8	10
Computer Systems	0	2	2	4
Theory	0	0	0	0
Total	2	14	20	36

(Men and women are equally represented in each cell)

Measures

The questionnaire measured five independent variables: sex, citizenship, age, area of concentration, and year in the program (see Table 5.2 for complete variable list). Citizenship was a dichotomous independent variable operationalized by either North American (US/Canadian) or foreign. Area of concentration was broken down into the four major areas of computer science represented in the department: artificial intelligence, computer systems, programming systems, and theory. Year in the program was divided into three categories. Initiates, first year students, were new to the doctoral program. Novices, second and third year students, were typically in the process of completing core qualifying examinations. Veterans, fourth year students and above, were typically working on theses.

The dependent measures addressed context (social structure and values), process (normative behavior), and outcomes (performance and professional values) (see Table 5.2). Social structure was operationalized as percent of students of each gender with same-sex advisor, status of the advisor, and the number of friends in the department. Values were operationalized as both attitudes towards the department and satisfaction with the department. Normative behavior was operationalized as time allocation where students were asked to report the number of hours in a typical week they spent doing various socialization-related activities. Performance and professional values were the outcome measures. Performance meant both academically, which was operationalized as grade on qualifying exams, and in research, which was operationalized as number of technical reports published. Professional values were operationalized as both career aspirations and attitude towards the profession of computer science.

Table 5.2
Independent and Dependent Variables and Operationalizations

Independent Variables	**Operationalizations**
Sex	Male, Female
Citizenship	North American, Foreign
Age	Date of birth
Area of Concentration	Artificial Intelligence, Programming Systems, Computer Systems, Theory
Year in Program	Initiate (1st year), Novice (2nd/3rd years), Veteran (4th + years)
Dependent Variables	**Operationalizations**
Context	
Social Structure	Percent of same-sex advisor, Status of advisor, Number of friends
Values	Attitudes toward department, Satisfaction with department
Process	
Normative Behaviors	Time allocation
Outcomes	
Performance	Grades on qualifying exams, Number of technical reports published.
Professional Values	Career aspirations, Attitudes towards the profession

The Respondents

The response rate was 89% for matched men and 78% for women. Of the thirty students, five were foreign and two did not specify. The average respondent was twenty-seven years old and had been in the program four years.

Preliminary Analyses

Correlation matrices for the groups of independent variables and the five sets of dependent scales verified that individual items measured different things. In only two instances did variables correlate above the r=.7 level. Age and year in the program were significantly

correlated (r=.7893, p=.000); thus only year in the program was considered for further analysis. Satisfaction with the kind of requirements and the number of requirements were also significantly correlated (r=.7300, p=.000). Thus these two items were averaged into one "satisfaction with requirements."

Comparison of matched men with random men revealed that men in the matched sample differed hardly at all from the random sample. The only differences were in the number of jointly authored papers published, feelings of anonymity, and belief of having similar values to the faculty. The random men had published more jointly authored papers (m=1.67) than the matched men (m= 0.44) (p = .027). They also agreed more strongly that they felt anonymous in the department (p = .030). The matched men agreed more strongly that their values were similar to those of the faculty (p = .027). Due to the small number of differences and the apparent un-relatedness of these differences, it was assumed that the men in the matched sample are representative of men in the department. The remainder of this paper focuses on only the matched men.

The independent variables of area, year in the program, and citizenship were also investigated. Area of concentration and year in the program were not good predictors of differences in the independent variables of interest. Not surprisingly, year in the program affected only two items: the number of jointly authored papers presented at conferences and the amount of time spent preparing for qualifiers. Veteran students had presented significantly more papers (m=1.73) than initiates (m=0.17) or novices (m=0.00) ($p < .05$) and spent almost no time preparing for qualifiers (m=2.38) in comparison with initiates (m=32.50) or novices (m=9.50) ($p < .05$).

Area of concentration was relevant to three significant differences. Programming systems people published significantly more jointly authored papers (m=1.11) than computer systems people (m=0.28) ($p < .05$), but there was no difference between them and AI people (m=1.00). AI people were more satisfied with their financial support (m=6.50) than programming systems people (m=5.00). And computer systems people were more likely to plan to work in industry (m=4.67) than AI people (m=3.41). Neither year in the program nor area of concentration affected any of the attitudes.

Citizenship affected satisfaction with the other students, desire to know more faculty, and importance of prominence in the field. The North American students were more satisfied with the other students (m=6.17) than were the foreign students (m = 5.25) ($p<.05$). The North American students expressed less desire to know more faculty in the department (m=2.87) than the foreign students (m= 4.00) ($p = .085$). It was more important to the US/Canadian students to be prominent in the field (US/Canadian m = 5.00; foreign m = 3.60) ($p = .076$). The foreign students, however, were more certain that they would do computer science research for the rest of their professional lives (m=6.80) than were the US/Canadian students (m= 5.39) ($p = .014$).

Findings

Context: Social Structure

Advisors

Most students had advisors who were teaching faculty -- professor, associate professor, or assistant professor. Some students in the department had chosen two faculty members to jointly advise them. Proportionally more women (28%) than men (15%) had more than one advisor, but this difference was not statistically significant. Men and women students

in the department did not systematically vary on the status of their chosen advisor or joint-advisors. They did vary in the proportion of same-sex advisors. The proportion of male students with same-sex advisor was 99%; the proportion of female students with same-sex advisor was 6%.

Friends

Graduate students in the computer science department typically had more friends in the department than outside the department. The average was five friends in the department and four elsewhere. There were no difference between men and women.

Context: Values

Attitudes Towards the Department

Students were very positive about the department (see Table 5.3). While they wished they knew both more faculty and students, they did not feel anonymous in the department. Those surveyed believed that the department treated students equally.The respondents seemed to be happy with the department -- they did not agree they could be at a different school as long as the work was similar, they agreed with the departments policies, and were unlikely to leave the program.

Men and women differed on two items: desire to know more faculty and leaving the program. Women wished they knew more of the faculty more strongly than men ($p=.011$). Women were not as firm as men in their assertion that it would take little change in their present circumstances to cause them to leave the program as men were ($p = .083$).

Table 5.3.

Measures of Attitudes toward the Department

(1=disagree; 7=agree)

Departmental Attitude Item	Mean	F	M	P-value
I am proud to tell others that I am a doctoral student in this department	6.23	6.00	6.25	.642
I wish I knew more of the faculty in this department*	4.60	5.64	4.44	.011
Often, I find it difficult to agree with this department's policies on important matters relating to its students	2.57	2.29	2.81	.184
I could just as well be at a different school as long as the type of work was similar.	2.40	2.50	2.31	.729
I feel fairly anonymous in this department*	3.44	2.93	3.75	.189
It would take very little change in my present circumstances to cause me to leave the program.	2.20	2.68	1.63	.083
Students are treated equally in the department	4.83	4.50	4.86	.532
I know very few of the faculty members in the department*	4.22	4.36	3.69	.140
I wish I knew more of the graduate students in the department	3.31	3.71	3.25	.350

* Items were reverse-scored.

Satisfaction with the Department

On ten seven-point Likert scales measuring satisfaction with the department, the means for all ten items were in the positive range (see Table 5.4). Students were most satisfied with the facilities and secondly with the department in general. Satisfaction with advisor and satisfaction with the intellectual environment were equal and students were similarly content about the quality of the faculty. The satisfaction with the requirements in the Ph.D.

program were roughly equivalent and still very positive, as was the satisfaction with the other students. People were least satisfied with the social environment, yet even that item was in the positive range.

There were only two satisfaction items where men and women differed marginally. Women reported being more satisfied with the other students than men ($p = .100$); and men were more satisfied with the amount of financial support they receive ($p = .066$) although both groups actually received the same amount of support. Men were also more satisfied with the department in general, although the result was not quite significant (see Table 5.4).

Table 5.4

Mean Response to Satisfaction Items on a Scale of 1 to 7

Satisfaction Item	Mean	F	M	P-value
Requirements in the Ph.D program	5.79	5.46	5.84	.301
Your advisor	6.03	5.75	6.06	.557
Quality of faculty	5.98	6.07	5.97	.772
Facilities	6.13	6.14	6.13	.965
Other students	5.75	6.23	5.69	.100
Amount of financial support	6.35	5.79	6.44	.066
Intellectual environment	6.03	6.00	6.21	.450
Social environment	4.73	4.69	5.00	.526
Department in general	6.05	5.57	6.13	.105

Process: Normative Behavior

Time allocation

Graduate students spent almost all of their work time doing research (m=34.6 hours per week). Neither male nor female students had much experience teaching. The mean for each group was less than one semester. The average amount of time a graduate student spent teaching is very small (m=1.69 hours per week). The nine respondents who were teaching this semester spent an average of nine hours per week engaged in teaching-related activities. The eleven respondents who were preparing for qualifying exams spent an average of fifteen hours per week on that task. When talking about work-related things, students reported spending twice as much time talking to peers (m=4.11 hours per week) than faculty (m=2.13 hours per week). More time was spent socializing with people from the department (m=6.85 hours per week) than with people not from the department (m=5.18 hours per week); and people spent less than three hours per week attending lectures or classes that are not directly related to their work.

Outcomes: Performance

The typical graduate student had taken three of four qualifying exams with a B average, and had co-authored one published paper. More than 80% of the respondents had not yet published or presented at conference a paper they alone authored. But over half of them had jointly-authored a paper which was presented and just under half had published a jointly-authored paper. In terms of performance, academically men and women are not different. Grades on all four qualifying exams revealed no difference by gender. Research performance, as measured by the number of technical reports published, similarly revealed no significant differences.

Outcomes: Professional Values

Career Aspirations

While students were sure they would finish the degree (m=6.49) and that they would experience great stress (m=5.26) they were not as certain about their career plans. The students surveyed on average expected to do computer science research for the rest of their lives (m=5.64), probably in academia (m=4.56), and probably not in industry (m=3.76), although both are close to "don't know" on the scale. Similarly respondents see themselves as research managers (m=4.44) and not as entrepreneurs (m=3.30).

Although there were no differences in career plans, the women were less certain than the men that they would finish the degree at Carnegie Mellon (men m = 6.63; women m = 5.64; p=.024).

Attitudes Towards the Profession

Five items on the attitude scale measured attitudes towards the profession of computer science. Although students were able to imagine pursuing a career other than computer science, the respondents seemed to be committed to the profession based on the other professional value items such as holding similar values to the faculty, being as interested in computer science as one's peers, aspiring to be prominent in the field, and viewing computer science as a hobby as well as a profession.

The most dramatic gender differences appeared in attitudes towards the profession of computer science. On all but one of the five items men and women were significantly different, and in each case, the women's attitudes were less positive (see Table 5.5).

Table 5.5.
Measures of Attitudes toward the Profession
(1=disagree; 7=agree)

Professional Attitude Item	Mean	F	M	P-value
I find that my values are very similar to those of the faculty	4.58	3.92	4.67	060
It seems that my friends are more interested in computer science than I am*	5.92	4.07	2.73	.025
For me, computer science is like a hobby as well as a profession	4.97	4.21	5.63	.017
It is very important for me to be prominent in my field	4.87	4.07	5.56	.009
I couldn't imagine pursuing a career other than computer science	3.50	2.93	4.00	.104

* Item was reverse-scored.

Discussion

This study investigated four hypotheses about professional socialization and gender and found at least some support for all of them:

1) The social structure is less supportive for women than men.
2) There is no differences in the process of professional socialization based on gender.
3) There is no difference in performance based on gender.

4) Women are less committed to the computer science profession than men.

There was some evidence that the social support structure is less supportive for women than for men. There were fewer same-sex peers and role models, and in the interviews the women spoke of feeling isolated in their work. The women wished they knew more of the faculty than did men, and they also were more likely to agree that it would take little change in their present circumstances to cause them to leave the program. Women were less satisfied with the other students than men, and also less satisfied with the amount of financial support they received. There were no differences in the way men and women spent their time. There were no differences on the qualifier grades of men and women and there were no differences in the number of technical reports published. The women had lower commitment to the profession. They were less sure that they would finish the degree than men, and they had less positive attitudes towards the computer science profession. Shortcomings of this study and suggestions for future research are discussed in the next chapter.

Chapter Six
Discussion

Introduction

As hypothesized women found the socialization environment less supportive than men, but there were no differences in how they spent their time. Also there were no differences in performance, but the women seemed to feel differently about long term career plans and goals than men did. The most prominent differences between men and women were found in their attitudes towards the profession. Although women performed as well as men, they were significantly less committed to the profession of computer science as evidenced by their lower responses on all five of the professional attitude scale items. This rings true with what the women said in the interviews about the paradox of happiness and success.

Four Alternative Explanations

- Men and women inherently value and aspire to different things in life.
- Differences in long-term career aspirations are the result of culturally ingrained beliefs about the roles of men and women.
- The different professional values of men and women are due to a negative graduate school socialization experience that was not adequately captured in this study.
- The larger professional environment does not provide the same opportunities for women as for men.

It may be that women and men are inherently different in terms of their professional commitment. The difference may be biological or genetic. This idea is consistent with many revisionist feminist writings that call for scientific reform, or a complete transformation of the scientific institution including higher education (Rose, 1983; Keller, 1985). Following this line of argument, there is nothing short of a major overhaul that will lessen the plight of women. The more common sentiment is that there are few

substantiated inherent gender differences and culture is a better explanation (Frieze et al., 1978).

Males and females are socialized differently from early on. The gender differences in professional values may be the result of this basic socialization process. Men and women might have appeared with the same differences in professional attitudes before they entered graduate school, or even before they entered college. In this case, the gender differences are not due to a negative professional socialization experience, but rather to a role conflict that is experienced by women (Farmer, 1987).

The third plausible explanation of the findings is that the differences are, as hypothesized, due to a negative graduate school socialization experience. This study however, may not have been devised well enough to capture the negative experience. The gender differences may in fact be due to the reduced social support structure and the lack of role models, but the questionnaire did not tap this directly. Or it may be that the negative socialization experience is extremely subtle and could only be captured through rigorous analysis of daily interactions, i.e., content analyzing all of the conversations women and men have with faculty and peers.

A fourth plausible explanation has to do with the larger professional environment not the immediate socialization environment. As discussed in Chapter One, there are few employed doctoral computer scientists. In addition, in 1981 the average annual salary for a man with a Ph.D. in computer science was $35,400, whereas for a woman it was $27,600. Furthermore, the ratio did not improve with increased years of experience (National Science Foundation, 1984, pp.147-148). Thus, although the context in which socialization occurs at Carnegie Mellon may be equitable, the receiving profession may not be. Women may be aware of this fact and may adjust their aspirations accordingly.

Carnegie Mellon may be unique in its supportive socialization environment. Things could be worse. Graduate school at The Massachusetts Institute of Technology (MIT) has been compared to being admitted to a fraternity (Sidner, 1979). Like fraternities, males dominate at MIT, installing rites and rituals which are difficult for women. The female graduate students and research staff in the Laboratory for Computer Science and the Artificial Intelligence Laboratory at MIT wrote a report of their experiences in this male-dominated setting (MIT, 1983). This report, entitled *Barriers to Equality in Academia: Women in Computer Science at MIT*, described discriminatory behavior that damaged both professional and social identity. The women felt patronized and insulted. Their qualifications were slighted and their competence questioned. They received unwanted male attention that hindered their ability to work successfully. The MIT socialization experience appears to be quite negative for women. It may be that the few women who succeed in earning Ph.D.'s from places like MIT are cynical and hardened. Thus, these few female role models in the larger profession convey negative attitudes that might lessen the commitment of others who are looking to them as examples.

Shortcomings of this Study

Professional socialization is a dynamic process which occurs over time. The best investigation of the process would be longitudinal to capture subtle changes occurring during the socialization years. In the current situation a longitudinal study was not possible. This investigation examined a group of people at different stages in the socialization process in a single time frame. Because of the small number of women in a given year, tenure could not be accounted for in any analyses.

Much of the data collected was qualitative. Along with the interview data, and much of the historical data, the questionnaire data were largely subjective. Students were asked if they

desired to know more faculty members rather than how many faculty members they knew. While social structure and performance were measured quantitatively, departmental and professional attitudes were not. In fact there were very few professional value items measured at all. Because the study focused on the immediate socialization experience, the number of questionnaire items on professional attitudes was small in proportion to the number on more immediate aspects of professional socialization.

Recommendations for Further Research

This study suggests that there are gender differences in career commitment. Future research must investigate whether these outcome differences existed before students entered professional school, or whether they were a result of the socialization process.

Policy Implications

Assuming that men and women are not inherently different in terms of professional commitment, then the gender differences may be the result of a socialization process or unequal opportunities in the receiving profession. This process may occur at the professional level; or it may occur throughout the student's life and be part of a cultural process. In either case there are measures that could possibly reduce the gender differences in professional values and commitment that were hinted at in this study. Care must be taken to eliminate even the most subtle gender distinctions. Women role models should be visible, if not as faculty members, as invited speakers. Also, women students in the program may need extra support because they are in a minority in the department. It may be that lower career commitment is due to an inhospitable receiving profession. That being the case, universities must take care to avoid discrimination in their hiring and promotion practices. Similarly academics must extend their commitment to gender equity by wielding their influence over their colleagues in industry.

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APPENDICES

Appendix 4.1

Diane Burton
5721 Forbes Avenue
Pittsburgh, PA 15220

August 26, 1986

Dear Ms. :

My name is Diane Burton, and I'm a senior in the Social and Decision Science Department. I am writing an honors thesis this year, the topic of which is socialization to the computing profession. My study is jointly sponsored by the Committee for Social Science Research in Computing (CSSRC) and my thesis advisor is Professor Lee Sproull. Basically, I am interested in doing a sociological narrative about women in computer science. Specifically, I would like to record experiences and reactions to this typically male-dominated field.

I would like to talk briefly with you at your convenience to hear about why you decided to get a Ph.D. in computer science, and about your initial reactions to CMU and the C.S. Department. Of course the interview will be treated confidentially and I will protect your anonymity. I'll call in a few days to see about scheduling a time when we could talk. In the mean time, if you have any questions or I can clear up any details, please feel free to contact me. My home phone is 343-4172, and my electronic mail address is mb2w@topsb.

Thank you very much, and I hope to hear from you.

Sincerely,

Diane Burton

Appendix 4.2

Interview Guide

Family background
- parents occupation?
- parental support?
- siblings?

Decisions to enter computer science
- experience with computers?
- important events?
- influential people?

Decision to get a Ph.D.
- important events?
- influential people?

Decision to go to Carnegie Mellon
- other programs considered?
- reasons for choosing CMU?

Perceptions of the Computer Science Department
- environment?
- peers?
- faculty?
- work?

Career aspirations
- finish the degree?
- stay in computer science?
- work in industry or academia?

Being a woman in computer science
- helped or hindered success?
- differences along the way?

Appendix 5.1
Computer Science Graduate Studies at Carnegie Mellon

Please take a few minutes to complete the following questionnaire. It is an investigation of what it is like to become a professional computer scientist. All information will be used for research purposes only and will be kept strictly confidential. After you have completed the questionnaire, please return it via campus mail in the attached envelope. Thank you for your help.

Background

1. Name _____

2. Gender: male _____ female _____

3. Where and when were you born?_____. 19 _____.

4. Including this year, how many years have you been in the computer science doctoral program at CMU? _____

5. What is your area of concentration?

   _____ Artificial Intelligence _____ Computer Systems

   _____ Programming Systems _____ Theory

6. For each year indicated below that you have been in the doctoral program who was/is your advisor?

   First year _____

   Second year _____

   Third year _____

   Currently _____

7. How many close friends do you have from the department? _____

8. How many close friends do you have from outside the department? _____

9. Since you've been a graduate student at Carnegie Mellon:

   a. How many solo-authored papers have you presented at conferences? _____

   b. How many solo-authored papers (not technical reports) have you published? _____

   c. How many papers for which you are a joint author have been presented at conferences?_____

   d. How many jointly-authored papers (not technical reports) have you published?_____

Appendix 5.1

Time Allocation

10. Approximately how many hours of your time in an average week this year do you spend doing the following:

_____ Teaching-related activities.

_____ Research-related activities.

_____ Preparing for qualifiers.

_____ Talking with peers about work-related things.

_____ Talking with faculty about work-related things.

_____ Socializing with people from the department.

_____ Socializing with people not from the department.

_____ Attending lectures or classes that aren't directly related to your work.

Appendix 5.1

Feelings about the PhD program

Using the indicated scale, please rate the following statements.

1 – 2 – 3 – 4 – 5 – 6 – 7

totally dissatisfied **neutral** **totally satisfied**

11. How satisfied are you with the following:

_____ Number of requirements of the PhD program (e.g. # of quals)

_____ Kind of requirements of the PhD program (e.g. quals, area qual)

_____ Your advisor

_____ Quality of faculty

_____ Facilities

_____ Other students

_____ Amount of financial support

_____ Intellectual environment

_____ Social environment

_____ Department in general

Appendix 5.1

Attitudes Towards the Department and the Profession of Computer Science

Using the following scale, rate each of the following statements.

1 – 2 – 3 – 4 – 5 – 6 – 7

totally disagree **neutral** **totally agree**

12. _____ The only thing that matters in judging students is the quality of their work.

13. _____ I am proud to tell others that I am a doctoral student in this department.

14. _____ I wish I knew more of the faculty in this department.

15. _____ Often, I find it difficult to agree with this department's policies on important matters relating to its students.

16. _____ I could just as well be at a different school as long as the type of work was similar.

17. _____ I feel fairly anonymous in this department.

18. _____ It would take very little change in my present circumstances to cause me to leave the program.

19. _____ I find that my values are very similar to those of the faculty.

20. _____ It seems that my friends are more interested in computer science than I am.

21. _____ Students are treated equally in the department.

22. _____ I know very few of the faculty members in the department.

23. _____ For me, computer science is like a hobby as well as a profession.

24. _____ It is very important for me to be prominent in my field.

25. _____ I couldn't imagine pursuing a career other than computer science.

26. _____ I wish I knew more of the graduate students in the department.

Appendix 5.1

Vision of the future

Using the indicated scale, please rate the following statements.

1 – 2 – 3 – 4 – 5 – 6 – 7

very unlikely **don't know** **very likely**

27. How likely is it that you will:

_____ Finish the PhD degree at Carnegie Mellon

_____ Experience great stress while finishing the degree

_____ Do computer science research for the rest of your professional career

_____ Become an entrepreneur

_____ Become a research manager

_____ Work primarily in academia

_____ Work primarily in industry