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ABSTRACT

Despite the continuing expansion of high-tech job opportunities, the literature indicates that many women are still socialized away from technology careers. The experiences of 12 women who have taken technological career paths and excelled in their fields were examined to identify factors that might have contributed to their excellence. The 12 women were "purposefully" selected to include 6 "guides" (college-level teachers and women who have achieved managerial and/or artistic status in high-tech industries) and 6 "pathtakers" (graduate students in technological fields). During in-depth interviews, the women attributed their success in a mathematical, scientific, or technological (MST) profession to the following factors: awareness of and interest in technical fields; encouragement of self-esteem; and encouragement of cognitive growth. It was recommended that parents and educators encourage females to pursue MST careers by taking the initiative to be proactive in helping girls understand from early childhood that women have a place in MST careers. Parents and educators can also work to change the negative perception of MST professionals as cold, nonnurturing people. Activities promoting development of the following skills and behaviors can be infused into girls' learning and play: critical thinking, reflective thinking, teamwork, question asking, and risk taking. (Contains 81 references.) (MN)

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Perspectives From The Field: The Socialization of Females With Regard To A Technology-Related Career

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Overview

Within the past few decades, after a hard fought agenda for women's rights, females have begun to make strides toward greater economic equity. Meanwhile, technology has become an increasingly important part of the modern economy, moving indispensably into the realms of science, business, and government, as well as the home itself. This greater use of technology implies that if women are going to continue moving toward increased economic strength, they will have to incorporate the use of technological skills as part of their power base (Brzowsky, 1998; Pazy, 1994; Spender, 1995; U.S. Bureau of Labor Statistics, 1997).

Yet, at a time when high-tech job opportunities are expanding, the literature indicates that many women are still socialized away from technology careers (Goodnow, 1998; Maney, 1996; NCES, 1992; Sadker & Sadker, 1994; Urschel, 1996). Many females do not see the computer culture as people-friendly, let alone female-friendly, and thus can not see themselves flourishing in such an environment (Sanders, Koch & Urso, 1997). Only 16 percent of scientists, 6 percent of engineers and 4 percent of computer scientists in the United States are women (Poole, 1998). Furthermore, females hold less than 15 percent of professional jobs that require a college degree in mathematics, science, and/or technology (Goff, 1997; Hutchinson & Kung, 1994; McLean, 1996; U.S. Bureau of Labor Statistics, 1995).

On the other hand, it should be noted that since this study was originally conceived late in 1997, tremendous changes have occurred within the technology field. Many of these changes, such as an increase in the number of video games that include

girls' play preferences, and the growing use of the Internet by many girls and women, have already begun to make mathematical, scientific, and technological (MST) climates more female friendly. Such changes promise continued progress for women in MST fields. However, since the number of women in high-tech fields continues to be relatively few, it is my contention, as well as that of many academic researchers and the popular press, that much work remains (Brzowsky, 1998; Davis, 1999; Goodnow, 1998; Lewin, 1998; Poole, 1998).

Therefore, the purpose of this research was to investigate experiences of women who have taken technological career paths, and who have also excelled in these fields, so as to identify factors that might have contributed to their excellence. It is hoped that a study of these women's lives will better inform practicing and preservice educators so that future generations of females might see all careers as open to them (Binns & Branch, 1995; Gay, 1995; Goodnow, 1998). It is hoped that such data may provide insight into teaching and learning methods that will help maintain and/or foster girls and women's interest in MST courses.

Methodology

The problem of gender based differences in technology-related fields is a multidimensional problem with no one event operating in isolation. Such a complex issue called for process-oriented research which consisted of a qualitative, contextual, and developmental case study design (Merriam, 1988). Given the goals and purposes of this study, the overarching question that guided the research focused on asking, "What external and/or internal factors influenced, supported, and/or encouraged these women to become competent at a very high level in nontraditional, technologically related professions?" Sub-questions, which helped frame the semi-structured face-to-face Interview Protocol, were created to explore the participants' experiences within various spheres of their individual lives, such as academic, personal, and educational environments. The goal was to encourage participants' stories to emerge in natural

descriptive narratives as they spoke of family life, experiences growing up, earliest recollections of MST encounters, and current concerns and interests in their MST professional environments. This case study approach allowed the researcher (myself, hereafter referred to in the first person) greater insight into the rich collection of abilities, attitudes, perceptions, and relationships these excelling women had/have with technology, and facilitated a holistic view of gender socialization factors that encourage and/or discourage women from participating in technological professions. The choice of a career path as the unit of analysis allowed for cross case study of women within various technology-related professions, at various stages within these careers (Huberman, 1993).

Purposeful sampling was used. "Purposeful sampling is based on the assumption that one wants to discover, understand, and gain insight; therefore one needs to select a sample from which one can learn the most" (Merriam, 1988, p. 48). As such, the 12 participants selected for this study were females who have excelled in technological environments. For purposes of this study, there were two categories of women, "guides" and "pathtakers." Guide participants were comprised of 4 college level teachers in computer science, instructional technology, and/or related technological fields that have attained a minimum rank of assistant professor; and 2 women in high-tech industries that have achieved managerial and/or artistic status within their company to the extent they affect the companies' economic competitiveness. Pathtakers included 6 graduate students within computer science, instructional technology, and/or related technological fields. The research settings included the respective places of business, research labs, and classrooms in which the participants work and/or study.

In-depth interviews were conducted and audiotaped. Observations and document analyses were also used. Field notes were taken to provide a detailed account of activities related to observations and interviews. A journal was employed to chronicle my thinking, feelings, experiences, and perceptions throughout the research process. Subsequently, sub-questions and the overarching question were answered by interweaving data, via a

constant comparative method, that emerged from a variety of contexts within the participants' stories (Glaser & Strauss, 1967). Each particpant was given a pseudonym. In the remaining portions of this paper, I will: (1) address sub-questions and the overarching question; (2) suggest recommendations for further improvement of gender equity within MST educational and work environments; and (3) suggest MST gender equity related issues that need further research.

The Sub-Questions

In general, the ten main sub-questions in the Interview Protocol attempted to provide an overview for the "who," "where," "when," "what," and "why" of the participants' lives. To lend greater clarity and give synthesis to this discussion, sub-questions that address aspects of the same issues will be grouped together. In the sub-questions discussion, I will focus on both the universality and uniqueness inherent in many of the participants' experiences.

Sub-Questions One, Two, and Three

Sub-questions one, two, and three constitute different aspects of a single theme – why were the participants drawn to technology careers. Sub-question one asked, "What personal, cultural, and/or institutional factors provided a context for these women's developmental process?" and focused toward external factors. Sub-question two inquired, "Within what contexts did these women's attitudes, abilities and dispositions for using technology evolve?" and tended to elicit responses that veered toward internal factors. Finally, since the literature indicated a home environment has such an overarching influence in a child's life in terms of sexual stereotyping (French, 1990), as well as shaping the child's personality, abilities, and motivational attitudes (Eccles & Hoffman, 1984), sub-question three is included in this group. It asked, "What events in the home experiences, if any, reverberated into technological career choices?"

The data to determine why these participants were drawn to MST career paths emerged from responses to interview protocol questions such as: "Where did you learn

the skills for this profession?" and "What were some of your earliest experiences with mathematics/science or technology?" The reasons were varied and often complex. However, the data indicated that many of these women were often initially influenced by either an encouraging male figure within their personal sphere, and/or by a teacher in the educational sphere.

By imitation and identification with this adult, whether a teacher-parent in informal settings, or a professional teacher in academic settings, the participant patterned her procedures or routines after the teacher's style. Sissy noted, "I remember my 2nd grade math teacher...which kinda strikes me, that being such an early grade. But her being such a good teacher led me eventually to the math degree...and influences the way I teach now." Such responses confirm research that indicated the tremendous part an appropriate role model or mentor can play in the influence of a child's career choice (Wright & Hounshell, 1981).

Like Sissy, many participants commented that exposure to a strong female technological role model played a significant part in their choosing MST career paths. Germaine noted, "When I saw this woman computer science teacher, I was overjoyed. I was hopeful. Because I realized the door was open and that I had been putting this limitation on myself." Such comments coincide with research which maintained that role models perceived as more similar are more likely to be imitated (Becker, 1985; Maccoby & Jacklin, 1974).

On the other hand, many participants were influenced by role models of a different gender. For example, eight women indicated they had substantial encouragement of technical/mechanical knowledge growth from fathers, male siblings, and male peers. Sophie commented, "My father was a process engineer. He was a tinker and he encouraged me to be a tinker." However, these participants' experiences do not coincide with research which indicated that many fathers do not expect daughters to do well in MST related areas (Mann, 1994; Nelson & Watson, 1991; Poole, 1998). In light of the

excellence these women have been able to achieve in MST environments, this seems an important consideration.

While many participants had strong male influences, some of these same women also indicated they were drawn to MST careers because of their own innate interests and abilities. Rinky noted, "It was always a fascination with inventions. It was right from the start." However, in these cases, the child's interest was fostered by someone who recognized and supported her MST aptitudes. Such scenarios are reminiscent of educational philosophers who encourage the development of more student-centered curricula (Dewey, 1966; Rugg & Shumaker, 1998).

Others were drawn to MST careers for various reasons, such as Jo's psychological need for acceptance; "I went into computers to impress my parents, particularly my father." Some needed to put themselves through the rigors of such an experience to prove their intelligence to themselves. At least half were attracted to MST career paths because they found they could apply technology to other kinds of real world interests, such as teaching or proactive environmental objectives, etc. Then, too, technology was often seen as empowering and liberating for themselves and for others, both personally and economically. Rinky commented, "It's the dawn of a new information age. Technology professions offer equal opportunities." Madison added, "Information is power. I think women are beginning to see that."

Sub-Question Four

Sub-question four asked, "What play experiences, if any, helped mold choices for participants to enter technological fields?" Responses indicated that for many participants the infusion of certain low-threat, high-challenge play activities into MST related classroom teaching methodologies, as well as in informal activities, often captured their interests, as well as motivated them to further pursue MST endeavors. For example, Judy grew up under the tutelage of a father who allowed her to play in his garage while he worked. "Play gave me opportunities to explore the properties and functions of many of

the items (tools) without threat." Judy described learning to tinker and to build wooden trolleys, which she eventually sailed up and down the main street of town. She added, "A nonthreatening environment was absolutely essential to my creativity." Descriptions of similar activities by other participants reinforce research that maintained play is an activity which leads to other outcomes such as learning, and the process of unleashing an individual's creative potential (Pellegrini, 1995; Spolin, 1986).

The data also indicated that some informal computer learning activities took place within a low-threat, high-challenge play type environment, and these experiences often led the participants to become risk-takers, going further and further into technological aspects. For example, Sophie described being hired by the technical department of her college as a customer service representative because she was "nice." "But," she added,

> They had a Prestel keyboard...and the keys represented different characters like x's, and slashes with a perpendicular line and things...and you could put those together to make pictures and animations. It was fun. I made things like a coffee cup with animated steam coming out of it. It made me feel like I had an aptitude for technical things. I was teaching myself. Later, they made me responsible for more and more (technical) things...gave me my first full time job.

For Sophie, as well as other participants, such experiences led to a major expansion in their cognitive growth. These encounters echo research which indicated that people are at their most "mindful," when they are at play, their senses are fully engaged, and their physical and mental powers at their highest (Csikszentmihalyi, 1990).

Other play activities that had a direct linkage to MST career path choices were found in tinkering activities and video game playing, especially problem solving, and puzzle oriented games. For example, Avery remarked that playing Mahjongg "sharpened my mind...looking at different options for things." However, the participants' attraction for puzzle type games, such as Tetris and Mahjongg, goes against research that depicts girls as not comfortable with video games which emphasize puzzles or involve visual and

spatial tasks (Hi-D Girls, 1996). Again, this is a reminder that children are individuals, and their particular interests need to be addressed (Rieber, Smith & Noah, 1998).

Finally, in terms of play activities, the participants also indicated that other play venues such as team sports were especially helpful in learning attitudes or teaching them skills. These abilities included "how to be competitive," as well as "how to work cooperatively." The participants' comments parallel research that discusses team sports' complicated rules and strategies as learning avenues which prepare children for survival in work situations and social organizations (Lever, 1976; Mead, 1934).

Sub-Question Five

Sub-question five asked, "What educational experiences, if any, contributed to motivations for choosing technological careers?" As noted previously, teachers played a strong role in creating an environment that allowed the participants' interests in MST subjects to flourish. Likewise, learning situations that included low-threat, high-challenge play and cognitive activities were strong influences. For example, Judy described a grammar school class where the teacher helped students learn mathematical tables by encouraging them to make up rhymes and to sing them together as a class. She added, "It was a neat experience that was absolutely enchanting."

Hands-on applications and reality-based assignments were also high motivation factors. Germaine, for example, had an absolute passion for music. She remarked, "When I started to get hands-on experience using a Musical Instrument Digital Interface (MIDI) I began to understand how the computer behaved, and I think that encouraged me to go on and learn some more." This desire for real world contexts and hands-on applications echoes many feminist educators' perspective of women's preferred learning styles. Such styles are characterized by the necessity of personal connection (Gilligan, 1982; Walkerdine, 1984). For example, Chodorow (1978) and Keller (1983) indicated that women need to establish a relationship between themselves and the object they are studying.

Finally, the academic computer environment itself, with a combination of science, technology, and software, emerged as a strong influence for why some participants choose MST career paths. For these women, the intellectual challenge of critical and abstract thinking within these environments was key. Rinky remarked, "You tend to abstract things to make things general so that they can be used to understand the relationships." Such comments illustrate constructivist theories that describe "learning as occurring through interactions with one's environment or culture" (Rieber, 1992, p.94).

Nonetheless, the attraction toward critical thinking on the part of some participants, and these women's avowed need to work in environments that encourage such thinking, reminds us of the necessity to avoid overgeneralizations – such as "males only" having a preference for controlled abstraction (Kenway & Modra, 1992). On the other hand, the degree to which many of these same women also employed reflective thinking parallels feminist theories that suggest women's predominant way of knowing is derived from a need to balance both subjective and objective strategies (Belenky et al., 1986).

Sub-Question Six

Sub-question six asked, "Under what circumstances did these women become producers and consumers of new technologies?" In terms of the emergence of technological interests, there are two major categories: (1) the participants' being emotionally and mentally ready; and (2) a change in the participant's perspective concerning the use of technology. For some participants "being ready" simply meant letting their innate abilities and interests come to the fore. For three women, their overall technology career paths have a more linear shape that evolved in gradual, orderly revelation, with a few digressions here and there. These women were labeled "Type A's" (More Linear Career Paths). For others, labeled "Type B's" (Event Change Career Paths), there was a need to become mentally prepared to take on the discipline necessary to master technologically-related knowledge. With regard to the seven Type B's, their

career paths appear to have resulted from an unpredictable event from an outside source that triggered a sudden change in the participant's perspective of computer-related possibilities. A third group of women, labeled "Type C" (Multiple Beginning Career Paths), incorporated aspects from each emergence pattern. The two Type C's made career choices that were not defined in terms of any single technology initiation event because the typical sequence for this career path style appears to be fueled by a need on the part of the participant to continually invent and reinvent themselves as they undergo explorations of multiple facets of their own personality and abilities. Each of the two Type C participants was a Guide and tended to incorporate parts of former occupations.

Nonetheless, whether MST interests emerged early on or later in life, many responses indicated the strong impact that role models or mentors played in the participants' lives. These mentors offered the scaffolding so necessary for many children, especially girls, to take risks (Bandura, 1986; Mann, 1994; Vygotsky, 1978), and therefore must not be underestimated. Germaine commented,

> I think it's always helpful if you've got someone actively believing in you because you pick up so much on the feelings (of that person). I found myself doing things that I would never be able to do because (they) gave me the support to do it and the opportunity to do it.

On a somewhat different note, it should be pointed out that while each of these 12 women have all excelled as producers and consumers of new technologies, some seemed more content that others. This feeling of contentment appeared in many ways to have resulted from a "good technological match" between their personal and professional interests. For example, Judy stated that she had "authentic reasons" for doing her technologically-related work and could barely contain her enthusiasm to search for new technological frontiers. On the other hand, Marie is an example of someone who experienced work as a schism, on a daily basis, between her "artistic self" and a "mathematical, logical self." Because Marie's professional duties only involved the later

components, she was dissatisfied and appeared to be on the threshold of abandoning her current job. Such situations remind educators that interest in MST subjects is in many ways related to the will of the student to be engaged in such activities (Rugg & Shumaker, 1998). Thus, it is imperative for educators to discover and include the student's own interests as part of the MST curriculum.

Sub-Questions Seven and Eight

Sub-question seven inquired, "What perspectives associated with women's ways of knowing, if any, brought these women to technology?" Sub-question eight asked, "What ideas and values do these women bring to technology?" These sub-questions are grouped together because they tend to either directly, or indirectly, affect the responses to the other question. The phrase "women's ways of knowing" implies a gender-related, but not gender-specific, tendency to relate to the world through contextual preferences, to offer empathy, to tolerate ambiguity, as well as to make connections via intuitive, cooperative, interactive, and holistic ways of learning (Belenky et al., 1986; Gilligan, 1982; Kenway & Modra, 1992).

Given this definition, sub-questions seven and eight addressed the qualities these participants identified in technological professions that were also part of their "core" value system as women. In terms of these women's values, all 12 were drawn toward innovation and technological change via paths that, to one degree or another, sprang from motivations which included the traditional role of being nurturers, caregivers and caretakers. Judy succinctly stated, "This (work) is changing people's lives, it's enhancing their lives. That's where I get the buzz." Judy's idealistic efforts reflect those of the other participants who saw technology as a bridge between their knowledge and other people.

Such comments reinforce research which indicated that women value relationships with others as central to their lives (Rosser, 1989). In this regard, many of the participants have tried to incorporate more socially redeeming values into their highly

competitive technological worlds, such as work objectives that create mutually beneficial solutions to socially significant problems. Therefore, it is not surprising that many of the respondents enjoyed cooperative and collaborative aspects of their MST work environments. Jo noted, "You build one thing and somebody else builds something else. It's a team thing because all these parts have to fit together. I really like that."

Sub-Question Nine

Sub-question nine examined issues such as, "What encouragement and support can these women contribute to other women's technological participation?" The data indicated they have earned their way, finding technical solutions in problem solving situations. As such, they feel they have legitimate power in their professional lives. Sophie commented, "I've struggled to get where I am...gone through the competitive hoops. I take pride in my work...have the expertise to back up the title." Therefore, many understand they can serve as conduits for better understanding of women's roles in MST environments. As role models these women show how self-esteem can be built on the self-knowledge which comes from learning from mistakes, taking advantage of changing perspectives, and taking control over their own lives.

In terms of being risk-takers themselves, these women advocate a need for girls and women to become question-askers, to take part in discussions, and to voice their opinions. Many of the participants, especially guides, talk of "giving back" to other women, of moving into a "mentoring" phase rather than an "individual achievement" phase. For example, Judy spoke of her efforts in teaching technology skills to mature women students. She noted, "The work that I'm doing is giving them the chance to move out of the entrapment where they've been."

Sub-Question Ten

Sub-question ten inquires, "What obstacles did/do these women face in their technology-related career paths?" The responses indicated that some participants had to surmount many impediments. Socioeconomic difficulties, struggles with depression, or

low self-esteem proved to be barriers for many of them. Eleven of the twelve participants indicated a drop in self-esteem during their adolescent years. These experiences parallel developmental research, which indicated that during girls' middle school years, many experience depression and/or try to kill themselves (Gilligan, 1990; Kantrowitz & Kalb, 1998; Mann, 1994). These experiences also call for continued attention to girls' vulnerable middle school years, and for educators to find methods to encourage girls' MST studies during this crucial time.

In terms of restraints, bias was a formidable opponent. All participants dealt with at least one occurrence. Some incidences were blatant and overt, such as Jo's loss (in the 1970's) of a full mathematics scholarship to college when the funding committee realized she was a woman. Jo noted, "It was awful. But what was really awful was that my parents were embarrassed that since I was a girl I shouldn't be doing this." On the other hand, most participants discussed the more pervasive subtle gender bias found in today's MST environments. Rachel noted, "In graduate school our instructors would often refer to the men by the last name...like Resnick thinks...whereas with the women it was...Rachel thinks. The ideas of men were already classified as having authority." Such descriptions of overt and subtle bias reiterate gender equity literature that indicated female students have a significantly broader spectrum of problems in MST environments than do their male counterparts, and that simplistic remedies will be ineffective in closing this gap (Canada & Brusca, 1991; Fennema, 1993; Hesse-Biber & Gilbert, 1994). On an incident-by-incident basis, micro inequities may frequently appear to be negligible. Some participants even prefaced certain remarks by noting that some experiences might not be "significant." However, I found that incidences of subtle bias were all too often a part of the collective experience on an ongoing basis, and need to be addressed.

Finally, a plurality of these women have experienced, or are currently experiencing, conflict in terms of family and career choices. This is typified by Marie, who remarked,

I'm in a profession that completely feeds on knowing what the latest and greatest is...yet my opportunities for those are limited. (As a single parent) I don't have a lot of outside learning time. And I'm not willing to sacrifice my parenting responsibilities. So I find myself in a position of always being behind.

This section looked at the ten sub-questions individually. Next, the overarching question and sub-questions in the aggregate will be discussed. In forming this overview, links are made to previous research. In addition, consideration of new findings will be incorporated.

Overarching Question & Discussion

In the investigation of internal and/or external factors that aided the participants' success in technological environments, or hindered their progress, the following representative topics from the literature can be linked to specific data from this study.

1. Role models and mentors are important motivators (Bandura, 1986).
2. Same-sex role models are important to counteract stereotypes (Cobble, 1980; Maccoby & Jacklin, 1974).
3. Collaborative, cooperative learning environments work well for female students (Rosser, 1989).
4. Scaffolding is important to encourage risk-taking (Vygotsky, 1978).
5. Reality based assignments work well for female students (Hesse-Biber & Gilbert, 1994; Rosser, 1989).
6. Video game playing aids in developing technology skills (Provenzo, Jr., 1992). Play activities are often effective learning environments (Pellegrini, 1995).
7. The perseverance in mastering a challenge depends on whether the activity is perceived as personally satisfying (Cope & Kalantzis, 1990; Leper, 1985; Keller & Suzuki, 1988).
8. Quiet reflection aids in cognitive growth (Dewey, 1938).

In addition to the above, other themes emerged that offer slightly different explanations for why these participants excelled in MST environments. For example, each had either (1) a strong constructive and creative impulse to make things; and/or (2) a cognitive impulse to find out "how things work." In this regard, fathers, male peers, or siblings were especially important as role model/mentors in tinkering environments. When one looks at tinkering activities and the way these experiences aided the participants' MST knowledge growth, one cannot underestimate the power of a child's (especially a girl) playing with gadgets and gizmos. Sissy remarked, "I took physics classes because I could play with all those machines...making things happen."

Likewise, the infusion of play elements into more traditional MST learning environments emerged as an especially strong motivating factor, in terms of giving the participants freedom to find their own way. Similarly, question-asking and risk-taking were traits the participants shared. These characteristics appeared to have a strong impact on their ability to succeed in MST fields. Finally, many of these participants had inherent critical thinking and reflective skills in their MST toolkits.

While findings from this study, in connection with previous research, offer new approaches for improving gender equity in MST environments, it is first necessary to understand that such an undertaking is both complex and dynamic. Although it is generally agreed that educational venues are the most effective way to assure equal opportunities via legal and social mechanisms, it is also agreed that schools are part of a larger societal unit (Spring, 1998). Therefore, many social, political, and economic agendas come into play when trying to narrow down solutions for improving any particular concern. Obviously, any successful remedy for the "technological gender gap" will require a supportive climate from business communities, families, and schools in developing guidelines for effective collaborative planning (Rogers, 1965; Rogers, 1971; Sarason, 1982, 1993; Schrum, 1991).

However, since teachers, school leaders, students, parents, or community members may have different conceptions of equity, this makes the goal of achieving such an objective even more problematic (Spring, 1998). For example, one of the current barriers to further implementation of programs concerned with the improvement girls' school experiences is found among parents and educators who are afraid that boys are being shortchanged. This perspective is partially grounded in the rising number of women, as compared to men, enrolling in liberal arts colleges, as well as the current dilemma of a large high school drop out rate for boys (Lewin, 1998). Such conditions have fostered a backlash against girls' equity issues and ignited concerns over the many emotional and academic problems that boys face in today's educational and societal climate (Kantrowitz & Kalb, 1998; Ravitch, 1994).

While it is noted these boys' issues are important, it should be pointed out that the same 1998 U.S. Department of Education report that cited the greater enrollment of females in liberal arts schools also indicated that at most engineering and technical schools men are still in the majority (Lewin, 1998). Therefore, a continued need for vigilance exists on the part of gender equity researchers in terms of helping girls' academic pursuits in MST subjects. However, this researcher also upholds the viewpoint that the pursuit of a MST career must not be pushed as the only valid option for a girl. For example, Sara pointed out,

> I think one trap that women fall into is doing what's expected...as opposed to what's right for them...it's a matter of being able to embrace your own self and not just work in meeting everyone else's expectations. So, I think forcing women into technical fields if they are not comfortable is as bad as keeping them out.

With that in mind, I believe that true MST gender equity can be accomplished only by: (1) reducing and eliminating biases and stereotypes that manifest double standards between male and female children, while (2) treating each child as an individual with respect for who she or he is. To that end, I will next focus on recommendations to achieve this goal.

Overarching Recommendations

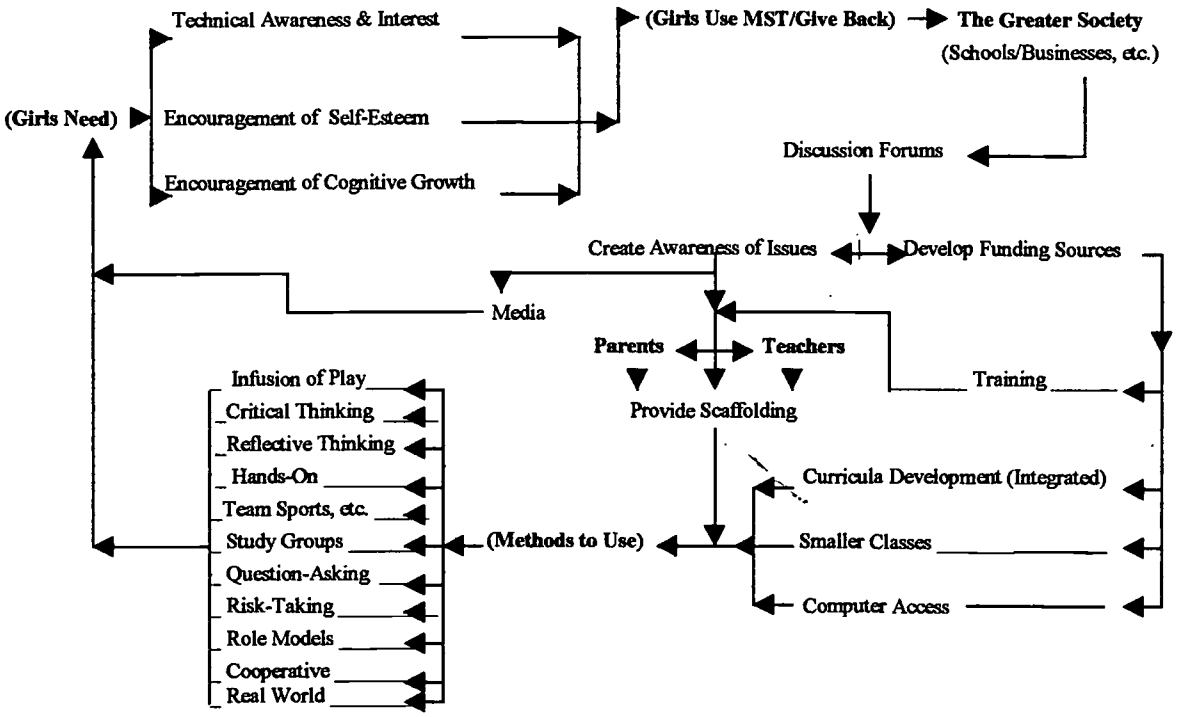
These suggestions encompass four overarching arenas for reducing and eliminating the technological gender gap: (1) parents and educators' role; (2) parental role; (3) educators' role; and (4) role of the greater society. The categories of "parental role" and "educators' role" are subsets, as well as extensions of the inclusive category "parents and educators." Therefore, general recommendations for parents and educators will be found under the first category, and will not be repeated under the individual categories. In each of the two-subset categories, more specific recommendations will be added. The term "educator" refers to both teachers and administrative members. Recommendations for the "greater society" will be addressed separately. In total, these four areas form an interwoven web, "an organically-related system of relationships" (Tyack, 1974, p. 15) (see Figure 6.1). Within this web, the human element is paramount. Based on participants' responses, one-on-one interactions often appeared to be a necessity for progress. In this regard, each person in a girl's circle of family, teachers, friends, and community members can begin from early childhood to help her understand that women have had, and do have, a place in MST professions. Likewise, women and girls can take the initiative to be proactive, to form study teams and ask questions, to set goals, to participate in a variety of activities, to seek out video games and software designed for girls' play and learning preferences, as well as to investigate cyberspace sites that are female-oriented, etc. These recommendations and suggestions are offered as gateways that might lead to a change in society's sensitivities, as well as avenues for the extension of our knowledge so that all students can receive the benefits of a sound and fair education.

Recommendations for Parents and Educators

Based on the participants' responses, as well as supporting literature, it is clear that parents and teachers often exert a strong influence on a girl's choice of either choosing a MST career path – or not. Therefore, it seems that parents, in general, need to

Figure 6.1

Interrelated Factors & Relationships in Reduction of MST Gender Gap



have greater participation in the life of the school on a regular basis. While this is already the norm for some, in other cases the school needs to become more proactive in seeking parents as partners in the MST education process (Tyack, 1974). Obviously, when parents are involved, they will have a higher chance of affecting policies that influence their children. The following categories emerged from the study as macro level improvement areas for parents and teachers in reduction of the MST gender gap.

Fostering Interest and Awareness

In fostering girls' awareness of, and interest in, potential MST careers, an overall need exists to change the negative perception of MST professionals as cold, non-nurturing people (Mann, 1994; Sadker & Sadker, 1994). Professional careers such as being a scientist, engineer, mathematician, or technician must be promoted so that girls see them

as relative to their lives. In this effort, girls need role models (Becker, 1985; Jackson, Mewborn, & Wieseman, 1997). Parents and educators need to empower girls with appropriate information to help them make informed choices. In addition, it is necessary that parents and teachers begin MST skills development in girls' early years, followed by more intense efforts in middle school. In high school and college, girls must be motivated to take advanced level MST courses. To accomplish these tasks, here are some general recommendations parents and teachers might consider:

1. Increase girls' exposure to historical role models by presentations of media depictions of female MST protagonists. For example, the video *Minerva's Machine* includes women's roles in the creation of the computer culture.
2. Enlist the help of girls in a collaborative search for age appropriate media with which to foster interest in MST areas, as well as enlist the help of a media librarian.
3. Help girls find real-life role models with whom to converse. In such encounters, the social and nurturing aspects of their jobs, such as how they help other people, might be emphasized along with the technological aspects.
4. Help girls have direct exposure to MST work environments by taking advantage of such campaigns as "Take Your Daughter To Work Day."
5. Foster females' interest in MST subjects and careers by encouraging them to interact with age appropriate software, web sites, or listservs that focus on MST careers for women. For example, Internet career networking sites such as *International Webgrrls* offer a forum to exchange job and business leads, as well as to teach and mentor (Downey, 1997).

Recommendations for parents. In terms of increasing girls' awareness of, and interest in, MST arenas, parents might incorporate the following suggestions:

1. Help children experience activities or hobbies they do not normally do by purchasing more gender-specific toys for either gender.

2. Set personal examples by utilizing MST contexts within the home, i.e., working on a computer if there is access to one. If there is no home computer, parents might encourage daughters to accompany them to an alternative site, such as the library, etc. Mothers, especially, might elect to do (or learn to do) more technical tasks.
3. Find out if there is a representative number of girls in the computer classes at the high school. If not, then parents might identify what can be done to increase participation.
4. Parents who work in MST environments might volunteer to be available as guides for on-site work visits.
5. Parents, especially women, who have experience in MST environments, might volunteer to serve as mentors, or guest speakers, to assist with hands-on activities, to provide field trips.

Recommendations for educators. In terms of increasing girls' awareness of, and interest in, MST arenas, educators might:

1. Include technological training for classroom teachers so they may be better MST role models, incorporating the use of technology into their classroom strategies.
2. Show relevance of MST to everyday life, by introduction of age appropriate discussions concerning ethical, cultural, and societal issues that surround MST fields.
3. Engage the use of web sites, listservs, software, other media, etc., that focus on age appropriate gender issues within a sociological or cultural context.
4. Encourage females' consideration of MST occupations by sponsoring career fairs that include discussions with working MST professionals.
5. Support the inclusion of up to date, age appropriate MST career information in the school media center, especially software packages that explore career opportunities.
6. Encourage and support the establishment of age appropriate MST mentoring programs.
7. Model classroom enthusiasm for teaching MST subject matter.

Fostering Self-Esteem in Girls

As evidenced by the participants' stories, one can see that words wound and that a subtle biased gesture can change a child's life. Therefore, parents and teachers need to become aware that what they say, how they say it, the language they use, what they do not say, what and how they teach, and even what they do not teach can all have a significant effect on the potential success or failure of a child. Therefore, parents and teachers need to renew efforts to assist girls with their transition to adolescence, and to address strategies for girls' self-empowerment beyond these developmental crisis years. As indicated by the participants' responses, girls' self-esteem can be enhanced by being exposed to "real" women talking about real issues. In cases where participants had difficult relationships (or no relationship) with their own mothers, there was an especially strong need for interactions with other women role models.

On another note, the participants' ability to ask questions in class, or after class in one-on-one situations with an adult teacher or parent played an important part in helping many of them develop self-esteem which aided in their achieving excellence in MST environments. Thus, it appears important to develop the questioning skills of girls and young women if they are to succeed in MST environments – to help them find their voices. However, the participants' responses also indicated that getting some students to ask questions is a subtle, delicate business. Therefore, it would appear that efforts in cognitive questioning strategies must also include the fostering of risk-taking tactics. Parents and educators might use the following suggestions for fostering self-esteem in girls and young women:

1. If representative portrayals of women's accomplishments are not included in curriculum materials, they might complain to textbook committees or the local school board. They might even take a proactive stance by volunteering to serve on such a committee.

2. Have discussions with students/children concerning the inclusion or absence of women in various media presentations within MST contexts. If there is lack of representation, adults and children might join forces in finding ways to promote awareness of the situation, and then, in turn, to change it.
3. Enroll in seminars and workshops that focus on the improvement of communication skills, such as listening abilities.
4. Use new communication skills to create "safe" dialogue environments that allow girls to voice their own opinions, ideals, and even fears.
5. Encourage girls' further question asking by taking time to answer questions that they do ask, as fully as possible. In instances where an answer may be unknown to the adult, a collaborative search for the correct information might be instigated.
6. Reflect on their own lives, in terms of being a role model, especially if involved with MST occupations, and share life experiences with girls.
7. Encourage risk-taking by helping students push through fear and frustration in small increments.

Recommendations for parents. In focusing on methods for parents to help increase girls' self esteem, they might:

1. Set up "free" unstructured periods of time to spend with daughters (and sons) where there is an opportunity for children to ask questions or just to talk. In terms of "what it means to be a woman," mothers might share memories of their own experiences growing up. (Although many parents already do this, it is useful to heighten awareness of the need for unstructured "sharing" intervals.)
2. Support a daughter's complaint of perceived school gender bias by, first, encouraging her to speak directly to the teacher concerning the incident. Then, if the girl is too uneasy to do this alone, go with her to discuss the matter with the teacher.
3. Talk to teachers and let them know concerns about gender bias in the classroom (Harper, 1996). Maybe there is value in visiting classes, either individually, or with

other parents. These visits could include watching the proceedings to see if there is an equitable use of equipment or other resources, or to see if everyone has an equitable chance to speak, etc. (See if teachers find ways to encourage quiet, shy students, whether they are boys or girls, to contribute to class. Observe if teachers find ways to help overly boisterous students, boys and girls, learn to listen to and respect their peers. In other words find out if teachers respond to each student as an individual, providing whatever type of support each individual needs.)

4. Encourage low-threat, high-challenge play conditions that offer appropriate risk-taking environments.
5. Encourage a daughter to gain further proficiency on the computer by letting her demonstrate new skills that she learned in school. Let her teach them to you.

Recommendations for educators. This section will focus on ways for educators to foster self-esteem in girls.

1. Pre-service and in-service teachers might participate in professional development experiences designed to support the reexamination of beliefs, expectations, and cultural sensitivities. Hirsch (1998) noted, "Nothing truly effective in the way of large scale policy change through federal, state, or local mechanisms can be accomplished until there is a change in mind by the ...two and a half million teachers" (p. 147).
2. Teachers might have a program for parents and community members on gender bias.
3. If stereotypes are encountered in materials, teachers might have discussions with their students on ways to overcome such stereotypes. Teachers might supplement existing curriculum materials with other books, web sites, handouts, etc.
4. Educators might explore utilization of classroom strategies that allow participation that is more equitable for both boys and girls by identifying and developing everyone's abilities.

5. Teachers might invite "regular" women, in addition to technological role models as guest speakers. For example, a mother who's raised six kid, who talks about what women can do (as women), could be invited as a guest "story teller."
6. If it is not already a part of the school administration, educators might help establish counseling services. If a school can only afford one counselor, perhaps some kind of "share" policy might be established with a neighboring school so that girls, as well as boys, might have access to a counselor of the same gender. This would be especially important during girls' adolescent period when they often become especially shy in talking about intimate things (Mann, 1994).
7. Middle school teachers especially might encourage adolescent girls to form study groups, so these girls can have a social network of peer support. Such a strategy might give girls the necessary encouragement that would allow them to speak out, maybe even risk an incorrect answer (Mann, 1994). Educators might help students network by arranging for times and rooms where groups could meet.
8. To further encourage risk-taking, teachers might infuse lesson plans with appropriate cooperative, low-threat, high-challenge play conditions, such as role playing, or staged debates, followed by open class discussions that help students learn to listen to each other. A mathematics class or a science class might include designing and building some structure, such as a dollhouse, with working lights and/or music.

Fostering Cognitive Growth in Girls

The participants acknowledged the many paths they traveled to MST careers, yet all indicated they were able to excel in MST environments partially due to their high degree of (1) critical thinking, (2) reflective thinking, and/or (3) problem solving abilities and skills. Therefore, parents and educators may strive to find ways to help girls (as well as boys) engage more fully in these practices. For example, hooks (1998) (she prefers to sign her name with lowercase letters) commented, "Without the capacity to think critically

about ourselves, and our lives, none of us would be able to move forward, to change, to grow" (p. 230).

In terms of methods to foster cognitive growth, question-asking skills among the participants appeared to be a gateway for them, as did the utilization of low-threat, high-challenge, play environments, such as computer games. These participants' responses concurred with cognitive psychologists and educators who maintained that effective instruction focuses on the active involvement of students in their own learning, with opportunities for interactions which engage the child's natural curiosity (Dewey, 1938; ISTE, 1998; McCombs, 1993). Similarly, engaging in team sports and team activities encourages problem solving in a social context, which according to the literature and the participants, help prepare children with organizational skills and competitive/ cooperative survival skills in work situations (Lever, 1976; Piaget, 1962).

Finally, some participants, as well as the literature, indicated a need for schools to actively seek integrated curricula. Sizer (1984), for example, described curricula that leave even the ablest and most devoted students in a swamp of intellectual confusion by the "jumble of subjects, none either thoroughly defined or related well to any other" (p. x). Specifically, with regard to MST subjects, the challenge is to develop curricula within contexts that have an appeal to learners of varying interests and aptitudes. To aid in cognitive growth among girls and young women, I recommend the following methods that parents and teachers might use:

1. Provide experiences, such as tinkering activities that lend a sense of wonder about the inner workings of machinery, tools, cars, computers, and household appliances. Interest might be fostered by an adult working side by side with the child.
2. Enhance higher-order thinking skills involved in problem solving by asking the student(s) to articulate what they are trying to do, why they are doing it, and why it is important.

3. Provide scaffolding support via books, computer software, and web sites, etc. For example, *Operation Smart Girls, Inc.* (http://www.feminist.com/girlsinc.htm), is a site where girls are involved in hands-on experiences, building and talking things apart, questioning and predicting, and developing an understanding of what scientists do.
4. Encourage cooperative game playing in MST environments since cooperative learning situations appear to have positive effects for all children (Johnson & Johnson, 1989), and play environments appear to foster learning (Pellegrini, 1995). For example, the use of software, such as *The Oregon Trail*, encourages pairs, as well as trios or quartets of students working together to share strategic decisions for the journey west. Cooperative technical play is an especially important consideration for children who may miss out on the parallel track of social learning by sitting in front of a computer for hours (Greenwald, 1998).
5. Encourage single-sex, as well as coed cooperative computer game playing sessions, since some research indicated that girls are at a disadvantage in mixed-sex computer groups (Underwood, Jindhal, & Underwood, 1994). In providing software, a full array of selections should be made available, especially games with girls' play preferences and learning styles, such as the CD-ROM *Girl Talk*, where girls (both individually, and in groups of up to four) are challenged to cooperate, use logic, reveal secrets, and solve puzzles (Davis, 1999).
6. Actively sponsor integrated curricula approaches in terms of the "widening of the areas of shared concerns" (Dewey, 1998, p. 34). For example, many girls fear mathematics – yet might love music. In an integrated curricula, the connection between these two subject areas (i.e., an eighth note, a quarter note, etc.) might be orchestrated into the course work in such a way the student can use the love of music to better understand mathematics, and to eventually transcend her fear.

Recommendations for parents. This section will focus on methods to increase the cognitive growth of girls. Parents might:

1. Sit with their daughters while they do homework, and encourage them to verbalize their thought processes. This fosters critical thinking.
2. Encourage girls to become involved in team sports, or to engage in similar team-oriented activities. Parents might foster this involvement by engaging in family sports activities.
3. Encourage family cooperative software and board game playing, etc. For example, in *SimSafari*, the parent(s) might help the child create a safari-park business, while balancing budgets, prey, and predators, etc. (Stauffacher, 1998).
4. Volunteer to act as sponsors for after-school or weekend sport and team activities.

Recommendations for educators. This section will focus on cognitive growth methods that educators might employ.

1. Introduce MST content by gateways that support the student's personal pursuits or interests. For example, use software that incorporates graphics instruction to entice girls who might be fearful of technology – yet love art.
2. Infuse brief intervals of quiet reflection time, especially after hands-on activities, or play learning experiences, into classroom strategies. Dewey (1938) noted such reflections mix observation and memory.
3. In terms of integrated curricula at the university level, educators might mainstream computer programming into an area where women are highly enrolled, such as women's studies, as well as entice female students to enroll in a computer programming course by offering such a course within a context that emphasizes both threads of knowledge (Smith, Del Rey & Everett, 1997).
4. Educators might foster the inclusion of students in both formal and informal team sports and/or activities. In terms of MST, environmental and computer clubs could be sponsored.

Recommendations for the Greater Society

To facilitate the community's understanding of MST gender inequities, educational, political, and business leaders need to organize and participate in roundtable discussion forums at the local, state, and federal levels. In turn, these members of the greater society might develop funding and policy strategies for the encouragement of women's greater participation in MST fields. Financial support is necessary to carry out reform such as awareness training, curricula development, etc. The question, of course, is "Do we as a society care enough about our daughters, sisters, and wives to take the necessary action to bring about gender equity in MST environments

Summary of Recommendations

These recommendations for parents, educators, and the greater society call for the fostering of girls' cognitive growth in MST subject matters, via teaching and learning methods that focus on strengthening their self-esteem, as well as increasing their interest in, and awareness of, technical skills. In this effort, it is necessary for the community to form a partnership with the schools and the parents (see Figure 6.1). Next, we will look at future research that might advance the creation of greater MST gender equity.

Future Research

As evidenced from this study, the problem of reducing the MST gender gap is complicated. Longitudinal studies are recommended to provide a deeper perspective of specific factors that influence women's choice(s) in taking or not taking a MST career path. There is a need for extensive tracking of students' exposure to various teaching methods suggested in these recommendations in order to provide quantitative and qualitative data on their effectiveness. There is a need to collect data on parental intervention techniques to determine which ones, if any, build a sense of trust, motivation, and cognitive curiosity in girls. There is also a need to determine effectiveness of particular methods, such as improved parental communication techniques in terms of promoting girls' question asking, or in helping girls verbalize cognitive thought processes.

Further research is necessary to determine how to effectively strengthen teacher competencies in MST content and gender equity pedagogy, so that a cadre of professionals can serve as resources and lead reform efforts. In brief, research in this area needs to look at the following: (1) What do teachers need to know in terms of improving MST gender equity? (2) When do they need to learn it? In addition, a need exists to develop teaching activities that incorporate and integrate recommendations from this study. Then, formative evaluations of these learning activities need to be conducted.

In focusing on recommendations for curriculum reform, such as integrated curricula, it is necessary to determine the status of integrative and transformational curricula approaches occurring in schools and colleges across the U.S. Research needs to investigate if such approaches are more effective gateways for women to enter MST careers. Since the literature indicated a need to increase both the number of women participating in MST, as well as a need for corporations to retain experienced women (Goff, 1997), it seems logical to determine what MST corporation programs, if any, are already in place that focus on the recruitment and retention of women. There is the necessity to investigate corporation forums which address problems that often fall disproportionately within women's concerns, to decide whether these programs have been useful, are worth continuing, and if so, what changes need to be made.

Summary

This study sought to investigate the experiences of 12 women who have taken career paths into traditionally male dominated MST areas, and who have excelled in their respective fields. The study began with a single overarching question, "What internal and/or external factors aided the participants' success in technological environments or hindered their progress?" The study was facilitated by a qualitative design that included in-depth interviews. These dialogues allowed me to form a holistic view of gender socialization factors that encouraged or discouraged these women's participation in technology-related professions.

The overarching conclusions of the study reinforced prior research, which indicated that role models, scaffolding, and collaborative, hands-on, reality-based assignments facilitate girls' interest in MST. New findings revealed that fathers, male peers, or male siblings played a strong part in motivating the participants to engage in tinkering activities, and provided scaffolding. Other findings indicated that girls need to be encouraged to ask questions and to take risks, even if they are only moderate ones. From the data, it appeared the infusion of play activities in MST environments also needs to be encouraged.

Finally, on a personal note, this study made a substantial impact on the researcher, herself. In these women's voices, I found echoes of my own thoughts. Most importantly, I became more attentive to my own part in being a role model for my students, and the need to provide scaffolding for them. The teacher/researcher was reminded over and over of the astonishing complexity of the learning process, and of the great variability among individuals.

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