An Ethnographic Investigation Into The Socialization of Females Regarding Technologically Oriented Career Paths

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Since this study was originally conceived in the late 1990s, tremendous changes have occurred within technology fields. Nonetheless, the technological gender gap represents a well-established societal pattern that continues at present (EDC, 2002; Oldham, 2000; Sanders, 2002; Taylor, 2002). “When it comes to today’s computer culture, the bottom line is that while more girls are on the train, they aren’t the ones driving,” states Pamela Haag, American Association of University Women’s Director of Research (AAUW, 2000). Furthermore, according to a recent study that monitored 8,000 participants in a variety of companies, simply learning computer skills alone won’t break down all the barriers that women face in the workplace. Houriuchi (2002) commented, “While the women in the study had equal computer skills as the men, they had unequal status.”

To aid in placing more women in the “driver’s seat,” this study investigated the experiences of twelve women who have taken career paths into traditionally male-dominated technological fields, and who have excelled in their respective professions. The study began with a single over-arching question, “What internal and/or external factors aided the participants’ success in technological environments, and/or hindered their progress? To present these findings, this paper opens with a brief examination of the current technological gender gap problem.

Overview

Historically, due to fewer educational and occupational opportunities, women have lagged behind men on the world's economic stage. However, within the past few decades, after a hard fought agenda for women's rights, females in many countries have begun to make strides toward greater economic equity. For example, women in the United States currently comprise approximately 55% – 60% percent of all collegiate students (Jacob, 2002; Lewin, 1998).

Meanwhile, technology has become an increasingly important part of the modern global economy, moving indispensably into the realms of science, business, and government, as well as the home itself. If women are not given equal opportunity to pursue technology-related careers, this can become a serious impediment, both to the development of technology, and to "the generation of wealth in an increasingly competitive world, " (Oldham, 2000). Yet, according to Oldham and the United Nations Commission on Science and Technology for Development, "fewer women than men pursue scientific or technological careers, and far fewer reach the top professional, managerial, or policy-making positions. " Houriuchi (2002) commented, "Nearly half of all U.S. men who use computers and Internet connection at work are employed in professional, executive or managerial positions compared with 33 percent of women."

While major cultural differences in some countries serve to discourage women from pursuing technologically related careers, other reasons, such as subtle discrimination, gender stereotyping, and the relative lack of women in policy and decision-making also affect this situation. Even in a progressive country, such as the United States, "Women are roughly 20 percent of IT professionals" (AAUW, 2000). Moreover, "Women make up just 9 percent of the recipients of engineering-related degrees, and receive less than 28 percent of computer science bachelor's degrees, down from a high of 37 percent in 1984. "

Although many concerned individuals and organizations agree there is a need to increase the likelihood that females choose careers in high-tech fields, there is also a great divergence of opinion on the reasons why many females don't (Jackson, Mewborn & Wieseman, 1997; Oldham, 2000; Sanders, Koch & Urso, 1997; Spring, 1998). In addition, the goal of achieving technological gender equity is even more problematic, due to the difficulty of defining recommendations, which would have universal validity when there is so much variation between countries, and between constituents of the same country. In the United States, for example, one of the current barriers to further implementation of programs concerned with the improvement of 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 dropout 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 boys' issues are important to this researcher, in terms of human rights and social justice, that does not diminish statistics indicating that at most engineering and technical schools men are still in the overwhelming 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 technology-related subjects.

Literature Base

This study had theoretical underpinnings in several research areas: (1) cognitive and social development; (2) educational philosophies; (3) play as socialization agent; and (4) feminist theory. Given this framework, the study examined the historical enculturation and socialization thesis of the technology gender gap. The literature indicated that women are socialized away from technology at every stage of life, from teachers' attitudes toward girls in grade school, to adolescent peer pressure, to the dearth of technology role models for high school girls, as well as the nonflexible programming found in many computer science departments (Binns & Branch, 1995; Gay, 1995; Goodnow, 1998; InGEAR, 1997; Mann, 1994; Sadker & Sadker, 1994; Spender, 1995; Turkle & Papert, 1990).

Since the literature which supports this study indicated that cultural, social, and educational barriers impede girls' and women's entry into traditionally male-dominated areas of technology in representative numbers, the purpose of this research was to investigate experiences of women who have taken technological career paths, and who have excelled in these fields, so as to identify factors that might have contributed to their excellence. It is hoped that the women in this study may offer insights into how women not only survive in this traditionally male-dominated culture, but also thrive. This is especially crucial when one contemplates that many girls may not see themselves flourishing in "unfriendly" technological environments, and as such may act on these misconceptions by failing to pursue technology-related courses beyond minimum requirements (Mann, 1994; Sanders, Koch & Urso, 1997; Streitmatter, 1994).

Design of Study

The literature indicated 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). The qualitative design included in-depth interviews with twelve women. Given that the research goal was to understand what brought these participants to a place in their lives where they excel in technology-oriented careers, this design facilitated a holistic view of gender socialization factors that encourage and/or discourage women from participating in technological professions. This type of design also allowed the researcher greater insight into the rich collection of abilities, attitudes, perceptions, and relationships these twelve women had/have with technology.

Six participants were technologically oriented career veterans (called “Guides”) who have been through the ins and outs of forging paths toward change during times, less favorable for women’s active involvement with technology. For example, Guide #1 commented, “My first experience with gender bias was my mother. She was against anything that would have been inappropriate in her generation for women to do…(but) I wanted to prove that I can do (technical) things also.”

On the other hand, six participants were younger women (called “Path Takers”) who have recently made technological related career-choices. These women included undergraduate and graduate students in computer science, instructional technology, and/or related fields. The concept in choosing these two categories was to use career paths as the unit of analysis. The researcher wanted to explore the trajectories of these women "over time," and thereby study how the characteristics of these women influenced their choice of career, as well as examine how the women were influenced by the technologies they encountered.

This study was grounded in a context that viewed technology as a cultural product. Such a context allowed the researcher to address the interrelated social processes that made/make technology familiar territory for these twelve women. Specifically, the study examined the personal, educational, and cultural spheres in which these women experienced enabling and disabling factors in their paths towards technology-related growth. The participants came from a variety of socio-economic backgrounds and diverse geographical origins (Georgia, California, New England, North Carolina, Oregon, Canada, New Zealand, and Australia).

Findings Linked to Literature Base

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

1. Role models and mentors are important motivators (Bandura, 1986). All participants concurred. The data indicated that parents, teachers, siblings, mates, friends, and/or media personas played a strong role in enabling the participants' career path choices. Fathers, in particular, played a large technological role in influencing many participants, as did a large number of male peers and/or male

siblings. Eight of these twelve women had fathers who served as technological role-model figures in terms of having math, science, or technology-related occupations. Path Taker #1 noted that her father was mechanically inclined, “His view was if you break it, you can fix it! That translated to where I am now. Just that philosophy -- you have to fiddle with it for a long time and be patient.”

In reviewing personal sphere statistics, 11 of the 12 women had at least one strong technological role model or emotionally nurturing person with whom they could identify. For the twelfth woman, teachers in the educational sphere played a tremendous support role in developing her self-esteem and technological motivation. In fact, all twelve participants believed that the ability to identify with a teacher, as a role model was a major condition for their doing well in areas related to math, science, and/or technology-related career paths.

Eleven women found inspiration from role models they encountered in “media.” These ranged from “real” persons, such as Albert Einstein, Martin Luther King, and Grace Hopper, one of the first women working with computers, to fictional characters such as the plucky independent heroine, “*Anne of Green Gables*.” Guide #2 was drawn to the *Tom Swift* series. “The character Tom would invent these marvelous machines and do things and be able to fix anything. It brought you out of this world into another world of imagination.”

2. Same-sex role models are important to counteract stereotypes (Cobble, 1980; Maccoby & Jacklin, 1974). While mothers played a strong role in psychological support, none served as technological role models. This is not surprising, considering that six of the participants were mature women, and as such, their

mothers came from a very different era, with less emphasis on the technological. Thus, women teachers often became the principle same-sex role models. Five women noted that they had at least one female teacher who served in this capacity, and three of these noted that having a female as a technological role model was an important factor in seeing themselves in these same roles. Guide #2, who later became an engineer, commented that having a woman principal in grammar school first let her know that "women could be independent and self-sufficient." She noted that such knowledge gave her the courage to further her education. In addition, "My female physics teacher challenged me to 'what science was,' and to 'possibilities.' She was a woman and it was interesting."

Conversely, Path Taker #2 pointed out that lack of information concerning women's technological contributions, such as Adele Goldstine's role in the creation of ENIAC, caused her to initially think, "Engineering is a man's profession." Discovering Goldstine's contributions changed her mental perception of her own role in being able to work with computers.

3. Student-centered instruction aids in the development of inherent interests (Dewey, 1966). Several participants were turned on to technology via computer graphic software that supported their artistic endeavors. Path Taker #2, who already had a strong appreciation of fine art and an acknowledgement of being "limited in ability" to create such art, reveled in finding software that supported her desire to "be an artist." Path Taker #3, originally a struggling musician – later a computer programmer, encountered a cognitive revelation when she was first introduced to electronic music – that technology was not "something separate from the arts,"

and was not something that she “couldn’t understand.” Thus, there was an increased incentive to learn how to use technology to create electronic music.

Conversely, Path Taker #6 spoke of how the lack of mathematical content identification held her back in a college statistics course. “If they could have related the statistics in a more realistic way to something that I could have held on to and felt something about…so that I could say this is an experience that I could possibly have…but I didn’t get that.”

4. Collaborative, cooperative learning/work environments work well for female students (Rosser, 1989). Many participants indicated that such conditions lent a positive influence to their learning and working efforts. Guide #5 commented, “The times I have been part of a team have been the most enjoyable in my life. I enjoyed the surge of excitement from working together.” Guide #4 noted that working with collaborative teams is “very freeing.” On the other hand, one participant relished competitive play, while four found the context of the situation determined which type of interaction they preferred. Guide #2 pointed out, “I like competition in sports. It helps in self-improvement…for focus and direction, instead of being wishy-washy…but I don’t view the same thing in the work place. I see that as much more cooperative.” While many participants did not appear to like overt competition, a majority of these women seemed to thrive in covertly competitive situations that include challenge and problem-solving elements, as well as in situations of competition with self. These women liked to “excel.”
5. Scaffolding is important to encourage risk-taking (Vygotsky, 1978). Each participant had some guiding adult with whom they could share their interests and

to whom they could "open up to." Path Taker #2 commented, "My skill came from being self - taught and being in an environment around people who had helpful experience to share."

6. Hands-on active applications work well for female students (Rugg & Shumaker, 1998). Eight participants noted they first became interested, or further engaged, in technology-related activities because of hands-on applied learning. Path Taker #1 commented, "I love putting things together…fixing things." Guide #6 noted, "Sitting at the computer, the world passed by…and I could be in my own environment, and I got instant rewards, because you could change the color, the layout, the activity, the wording. There was this sense of accomplishment."
7. Reality based assignments work well for female students (Hesse-Biber & Gilbert, 1994; Rosser, 1989). The participants saw content identification and/or teaching methodology as strong factors in becoming involved with technology-related career paths. Path Taker #5, who became a computer programmer, talked about designing a computer system for a dentist's office while she was an undergraduate. "It was my first real world experience with going in and dissecting a problem and coming up with a solution… taking something that works OK, and brainstorming it and coming out with something that would make lives easier. It was a kind of marriage between the technological and the creative."

Most participants were drawn to learning environments that dealt with real world issues. Six women spoke of the way they were turned off in classes if the material had no practical real world application. At least half were attracted to technologically oriented career paths because they found they could apply technology to other kinds of real world interests, such as proactive environmental objectives, or teaching, etc. Guide #3 remarked, "My proposal for my doctoral program was to look at how we could design both the hardware and the software so that we could make it more accessible to girls."

In this real-world application context, technology was often seen as empowering and liberating for themselves and for others, both personally and economically. Path Taker #6 added, "Information is power. I think women are beginning to see that." Guide #2 commented, "It's the dawn of a new information age. Technology professions offer equal opportunities."

8. Video game playing aids in developing technology skills (Provenzo, Jr., 1992). Several participants maintained that playing certain video games (Mahjongg, Myst, Tetris, Sim City, Atari, etc.) aided their cognitive and technological growth. Path Taker #3 compared the intuitive and creative way that she writes programming code to some of the experiences she had while playing electronic Mahjongg. "You have to move things and remember where other things are…try a bunch of different combinations to find matches and mates." Furthermore, it aided in "understanding how to approach something and narrow it down very quickly to what kind of problem it could be."
9. Play activities are often effective learning environments (Pellegrini, 1995; Rieber, Smith, & Noah, 1998). A variety of team and individual sports, as well as creative games and artistic pastimes influenced the development of mental skills and attitudes that enabled these twelve women to venture along math, science, and technology-related career paths. Perhaps the play activities that had the most

direct influence on the participants' technological career choices were games that involved technical or mechanical aspects. Four of these women indicated a preference for puzzle oriented or problem solving games such as electronic Mahjongg, etc. These types of video/computer games appeared to serve as strong motivational learning tools for these participants. For example, one path taker became really "hooked" on Tetris, the Russian puzzle game, when her college boyfriend introduced her to it. She commented that in comparison to other experiences with computers, that for the first time, "I was more in control, more comfortable…it was less intimidating. I just loved that."

A second major technical/mechanical play activity described by eight participants was "tinkering." For purposes of this study, tinkering is defined as a hands-on, non-confrontational creative activity that results in a sense of accomplishment from building or repairing something. Path Taker #2 commented on her father's role in fostering a tinkering aptitude, "When the lawn mower broke, he'd be like, 'what goes here? Why don't you think it's working?' He'd always take things apart and put it down in front of me."

Tinkering was found in a large range of activities. Path Taker #3 commented, "My sisters and I had a killer set of Barbie dolls. We'd build little shelters. We'd get elaborate with it…an imaginary world. I enjoyed the creative self-expression."

10. Adolescence is a crucial time for female students, both emotionally, as well as establishing interest in technology-related careers (EDC, 2002; Gilligan, 1990; Kantrowitz & Kalb, 1998). Nine participants experienced a mixture of negative

and positive environmental factors which contributed to self-esteems that appeared to ebb and flow with changing events. Path Taker #5 commented, “I was a weird combination of outgoing, but constantly being afraid of drawing attention to myself.” Four women commented that growing up they experienced some degree of trauma because of their high intelligence. Guide #5 noted that she “felt like an incredibly odd duck, three standard deviations out. I was anxious, intimidated, and awkward.” She attempted suicide in her early years.

Two participants’ families had no economic stability, which resulted in a lack of parental support and encouragement for the girls. Each had weak “self-starter” skills, and did not identify strongly with peers. Consequently, both had very little positive self-esteem during their adolescence. Of these two, Path Taker #3 also attempted suicide during her teen years. Conversely, Path Taker #4 had a more consistently high degree of positive self-esteem. She indicated that: (1) her parents, siblings, teachers, and peers were, in general, encouraging and supportive; (2) her family’s economic situation was stable and relatively secure; (3) she had innate social skills; and (4) she considered herself a “self-starter.”

In terms of disabling factors, nine participants commented on the adverse affects that negative encounters with particular teachers had on their initial career goals. Guide #4 remembers that she might have gone into engineering much earlier except for a “dreadful experience” of gender bias. Her high-school teacher made her feel like a social “geek” because she was better in physics than the boys in class. “It induced a tuned out kind of behavior (to science).” Another participant spoke of the role her mother played in creating an initial mathematics phobia -- she told “my sisters and me that girls were not good at mathematics, etc.” Only as an adult, when economic necessity reared its head, did this Path Taker take advanced math classes so she could pursue a computer science degree.

11. The perseverance in mastering a challenge depends on whether the activity is perceived as personally satisfying (Cope & Kalantzis, 1990; Leper, 1985; Keller & Suzuki, 1988). Many participants affirmed they learned and used what they wanted to learn, and what they wanted to learn was very much determined by what was relevant to them. After approximately ten years as an engineer, Guide #5 realized that she no longer had a passion for it. “I came to the conclusion that I’m clearly more interested in the intellectual,” such as Chaos Theory analysis. Now my passion in life is to help create space for real significant social change,” by bringing the “sciences and technology closer together on a personal level.”
12. Quiet reflection aids in cognitive growth (Dewey, 1938). Several participants noted that in a learning experience they frequently needed quiet time to integrate thought processes, especially if the process was complicated. Guide #3 remarked, “I tend to have to do that on my own…to make those connections. (For example), I was drawing railroad tracks from a distance perspective. You know where you place people and they’re smaller because they’re far away. I remember going into a serious understanding of how you could focus differently on things. Suddenly, I perceived that what I perceived was not what other people perceived and that other people didn’t perceive the same thing…different people would perceive it differently given where they were coming from…morals, backgrounds, previous experience.”

New Findings

In addition to findings that role models, scaffolding, and collaborative, hands-on, reality-based assignments facilitate girls' interest in technology-related career paths, other themes emerged that offer slightly different explanations for why these participants excelled in technology-related 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." While many participants were influenced by strong technological role models, some of these same women also indicated they were drawn to technology-related careers because of their own innate interests and abilities. Guide #2 noted, "It was always a fascination with inventions. It was right from the start."

New findings in this study also revealed that question asking and risk-taking traits were participant commonalties. In terms of question asking, the data indicated that as adults all of the women consider themselves strong question askers. The responses indicated that for some participants this skill was also highly present throughout their academic endeavors. On the other hand, asking questions in class was a great deal more difficult for others. This was particularly the case in subjects such as mathematics where some participants did not consider themselves as having strong skills. Nonetheless, many of these non-classroom questioners had the ability to find less public ways to acquire the information they needed to succeed. Guide #6 turned to her mother where they had "discussions over tea" concerning homework assignments. For others, such as Guide #2 and Path Taker #2, the strategy was to go to the teachers one-on-one after class. Guide #2 pointed out, "I tried to make sure that I understood what was behind everything...how it worked. Asking after class gave me a little bit closer relationship with the teachers where they could tell me a lot more. Not just the question, but go on and foster the interest."

All twelve participants considered themselves self-starters and risk-takers. Each of the women indicated that over time, in addition to asking questions, they developed at least one of the following self-regulated learning skills: (1) the capacity to seek out and read manuals or other information thick material (2) the capability to "play" with computer software until they are familiar with it, (3) the understanding of a need to "pump" up the volume in times of crisis, and (4) being able to seek help, such as forming a study group, or finding peer support.

While play has long been considered a learning tool for children, this study found the activity of "tinkering," provided a strong motivation environment for technical/ mechanical related learning. Tinkering provided an answer to, "How does it work?" This was especially true when the activity was coupled with strong role modeling and scaffolding. If one looks at tinkering activities and the way these experiences aided the participants' technology-related knowledge growth, one cannot underestimate the power of a child's (especially a girl) playing with gadgets and gizmos. Path Taker #4 remarked, "I took physics classes because I could play with all those machines…making things happen."

In terms of cognitive growth that emerged from the participants' play activities there were three common elements. First, the participants were deeply involved with the activity. Second, they were in a low risk environment, and finally they were allowed time for reflection. Eleven participants spoke of the sense of accomplishment they felt in challenge/problem solving play activities when they were able to understand the task, or figured out how it worked and then did it to the best of their ability.

Recommendations

While findings from this study, in connection with previous research, offer new approaches for closing the gender gap in technology-related 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. Since there are countries in the world where women may not pursue any career, much less one in technology, these recommendations are geared more towards progressive countries, such as the United States. 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 (Huberman, 1984; Rogers, 1965; Sarason, 1982; Schrum, 1991).

Nonetheless, this researcher also upholds the viewpoint that the pursuit of a technology career must not be pushed as the only valid option for a girl. Guide #4 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. I think forcing women into technical fields if they are not comfortable is as bad as keeping them out."

With that in mind, the researcher will next focus on some recommendations to close the technology gender gap. These suggestions encompass the role for parents, educators, and the greater society. The term "educator" refers to both teachers and administrative members. In total, these areas form an interwoven web, "an organically-related system of relationships" (Tyack, 1974, p. 15). Within this web (see Figure 1), 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 technology-related

Interrelated Factors & Relationships in Reduction of MST Gender Gap

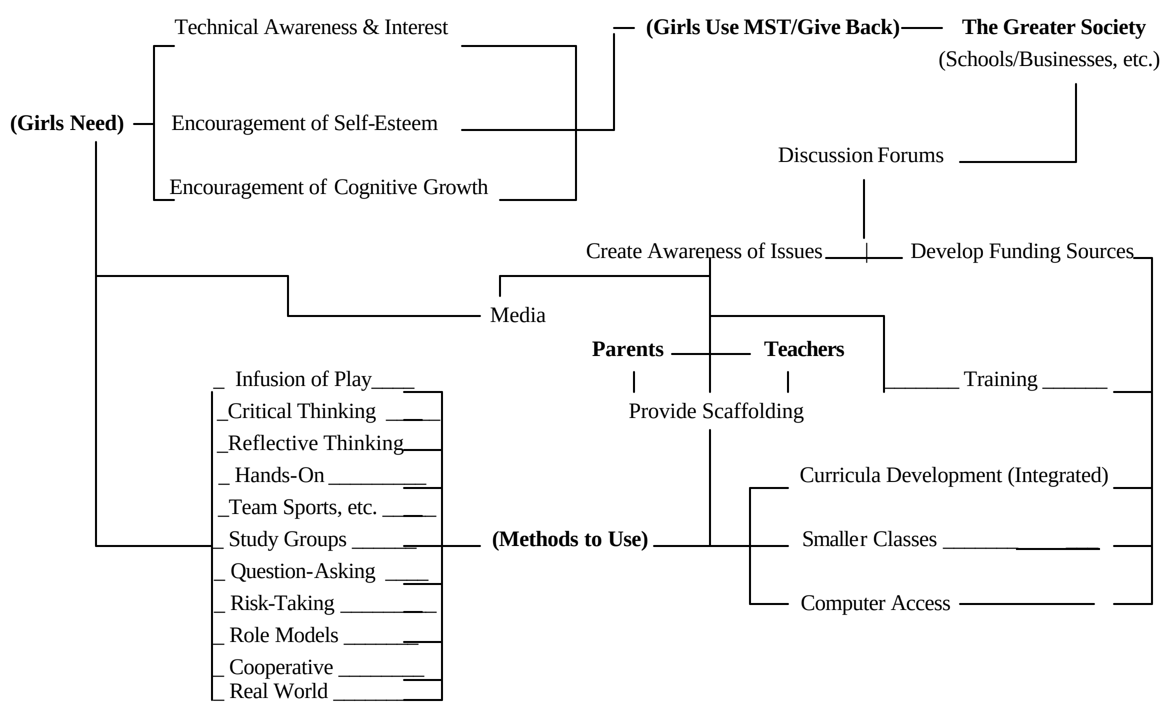

Figure 1

professions. If girls are not grounded in the fundamentals of math or technology in elementary school and high school, they “won’t have the skills and it’s very difficult to catch up (in college),” (EDC, 2002).

Likewise, women and girls can take the initiative to: 1) be proactive, 2) form study teams, 3) ask questions, 4) set goals, 5) participate in a variety of activities, 6) seek out video games and software designed for females’ play and learning preferences, and (7) investigate cyberspace sites that are female-oriented, etc. These recommendations 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. These suggestions call for increasing an awareness of technology’s relevance to female’s lives, focusing on strengthening their self-esteem, and fostering girls and women’s technological cognitive growth.

Recommendations for Raising Awareness of Technology-Related Careers

1. The need for day-to-day role models and mentors in the workplace and in the media was an issue these women often discussed. They were highly cognizant of their own roles in being role models themselves. To provide such role models:
    a. Increase girls’ exposure to historical role models by presentations of media depictions of female technology oriented protagonists. For example, the video *Minerva*’*s Machine* presents the history of the computer from a woman’s perspective, and includes women’s roles in the creation of this culture.
    b. Incorporate resources for women’s history, such as “4000 Years of Women in Science” at http://crux.astr.ua.edu/4000WS/4000WS.html.
    c. Set personal examples by utilizing technology within the home, i.e., working on a computer if there is access to one.

d. Encourage females' consideration of technology occupations by sponsoring career fairs that include discussions with working professionals.

2. Enlist the help of girls in a collaborative search for age appropriate media (software, web sites, films, etc.) with which to foster interest in technological areas. For example, Internet career networking sites such as *International Webgrrls* (www.webgrrls.com) offer a forum to exchange job and business leads, as well as to teach and mentor (Downey, 1997).
3. Find out if there are a representative number of girls in the computer classes at the high school. If not, then parents and educators might identify what can be done to increase participation.
4. Include technological training for classroom teachers so they may better incorporate the use of technology into classroom strategies, as well as being stronger role models.
5. Show relevance of technology to everyday life, by introduction of age appropriate discussions concerning ethical, cultural, and societal issues that surround math, science, technology fields, such as science as a tool to prolong life, or to create new life forms. Use www.troom.com as a site for girls who want to know about their world.
    a. Engage the use of web sites, listservs, software, other media, etc., that focus on age appropriate gender issues within a sociological or cultural context.
    b. Support the inclusion of up to date, age appropriate technology career information in the school media center, especially software packages and web sites that explore career opportunities, such as www.backyard.org for girls exploring a career in computer science.

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 greater gender equity in technologically oriented environments?" To this end, the following recommendations are suggested for action by the greater society:

6. Schools, communities, and businesses might form an alliance that supports:
   a. The funding of computer labs in schools, libraries, and/or civic centers, to ensure that girls (and boys) have adequate access to contemporary technology resources, as well as technical assistance for maintaining and using them.
   c. Technological outreach programs for families who suffer discomfort with certain aspects of technology or lack of basic computer skills, as well as basic skills in other technological areas might be sponsored by the greater society.

Recommendations For Raising Self-Esteem

The study indicated that 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 technologically oriented environments. Thus, it appears important to develop the questioning skills of girls and young women if they are to succeed. 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 technology-related accomplishments are not included in curriculum materials, they might complain to textbook committees or the local school board. 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. The Eisenhower National Clearinghouse (http://equity.enc.org/) is a resource for educators concerned about creating equitable conditions, as is The University of Georgia's InGEAR (www.coe.uga.edu/ingear).

2. Pre-service and in-service teachers might participate in professional development experiences designed to support the reexamination of beliefs, expectations, and cultural sensitivities. “Connections Across Cultures” is an online course inviting multiple perspectives into math, science, technology and engineering (www.wvmccd.cc.ca.us/mc/cac/).
3. Parents, educators, students should enroll in seminars and workshops that focus on improvement of communication skills.
    a. Use new communication skills to create “safe” dialogue environments that allow girls to voice their own opinions, ideals, and even fears.
    b. Encourage girls’ further question asking by taking time to answer questions that they do ask, as fully as possible, and if an answer is unknown to the adult, a collaborative search for the correct information might be instigated.
    c. Help students break down a major obstacle into manageable speed bumps, where small achievements can be accomplished.
4. 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.
5. Encourage a daughter to gain further proficiency on the computer by letting her demonstrate new skills that she learned in school, etc., and if you do not know them, then let her teach them to you.
6. Middle school teachers especially might encourage adolescent girls to form study groups, so these girls can have a social network of peer support.

Recommendations For Fostering Cognitive Growth

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, plays environments, such as computer games. 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, 1965). To aid in cognitive growth among females, I recommend the following methods:

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. An adult working side by side with the child, providing scaffolding might foster interest.
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. "How" and "why" questions might become the focus of discussions surrounding tinkering activities.
3. Provide scaffolding support via books, computer software, and web sites, etc. For example, a Michigan State University web site, http://www.msu.edu/~maloleyk/websites.htm offers nine links to sites developed for girls, 17 links to great resources for educators, and 10 links that serve as resources for women's history and issues of interest to women/girls.
4. Encourage cooperative game playing in technological 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. Parents and educators might encourage students to verbalize their thought processes. This fosters critical thinking.
7. 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).
8. Introduce technological 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.
9. 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.
10. 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).
11. Since many graduate classes are taught in the evening, and it is often difficult to find traditional "day care" during these hours, on-site childcare might be considered by graduate college facilities to aid students in the pursuit of MST careers. Several participants spoke of the difficulties of returning to graduate school while taking care of small children.
12. Graduate schools might especially consider the incorporation of more on-line education courses to aid parents in taking care of young children, while continuing to pursue technology degrees.

Summary

These recommendations for parents, educators, and the greater society call for the fostering of girls' cognitive growth in math, science, and technology-related 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.

We stand at the threshold of a future world full of technological possibilities. Obviously, it becomes a matter of concern to change the climate of computing and technology environments so women are encouraged to participate fully. Looking at the lives of women who have gotten through many socialization barriers to become extremely competent in their respective fields is a good place to begin.

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