THE FLORIDA STATE UNIVERSITY
COLLEGE OF EDUCATION

IMPACT OF A WOMEN’S PROGRAM FOR SCIENCE, MATHEMATICS AND
ENGINEERING ON UNDERGRADUATE WOMEN: ACTIVITY SYSTEMS ON THE
PERIPHERY

By

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To Asel Müge Kahveci
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ABSTRACT

National reports such as National Science Foundation’s highlight women’s disproportionate distribution and differential treatment in the science, mathematics, and engineering (SM&E) fields, in both education and the workforce in the US. Women are less likely than men to choose a career that involves SM&E, and are more likely than men to earn bachelor's degrees in non-science and non-engineering fields.

In explicit and implicit ways women have been discouraged from participating in the SM&E fields. Various feminist theory strands with different theoretical underpinnings bring explanations and possible ways of changing the patriarchal structure, and ways of political action to change the status quo. The need for support and encouragement is obvious for women already in college intending to pursue a major in a SM&E field. Comprehensive support networks can be and are established through programs for women entering college and willing to pursue careers in SM&E fields.

The context of this research was the Program for Women in Science, Engineering and Mathematics (PWISEM) established in 2001 by a Southern teaching and research university in the US. By providing a living-learning community, the Program offered role models, guest speakers, lectures (Colloquium), panel discussions, mentoring, advising assistance, research internships, tutoring, opportunities for field trips, and social events to encourage especially first-year women students to participate and succeed in the SM&E majors.

By interweaving the theory of situated learning/legitimate peripheral participation (at macro level) and the cultural-historical activity theory (at micro level) as the theoretical framework of my research, I constructed the notion of “activity systems on the periphery” and used it as a thorough theoretical lens. I explored the interactions and contradictions that affected the science identity formation of the PWISEM students, how they identified themselves as future scientists, and the key factors PWISEM involved in motivating and supporting women students in their intended SM&E majors.
The design of the research was dominant-less dominant, the dominant approach being qualitative and the less-dominant being quantitative. The qualitative approach involved multi-case study with three cases. The quantitative approach consisted of a pretest and a posttest, through which I compared PWISEM and non-PWISEM student groups over one academic year.

The Program was successful in fostering the participation and retention of undergraduate women in SM&E. The PWISEM women’s decision for a SM&E major was significantly higher than the non-PWISEM women and men. Such a result signaled factors discouraging both men and women from the SM&E majors. The strong emphasis on interactions, relationships, SM&E networks and the sense of community in the PWISEM was implicit determiner in the students’ decisions to pursue SM&E.

However, the women in the Program were more likely to internalize the status quo in the SM&E realms without actively challenging it (liberal feminist approach). To change the masculine culture embedded in SM&E, engaging in activism is essential. This research suggests that in fact, programs like PWISEM provide promising contexts for reforming the SM&E culture to be more appealing and inclusive of all.

I suggest that there can be both explicit and implicit ways of transformation within such contexts. The explicit transformation approach involves raising (difference) feminist awareness whereas the implicit approach is based on interweaving both sameness and difference feminist aspects. While the explicit approach focuses on developing women’s feminist identities, the implicit approach works to enhance other qualities than those of the Western and white man, via means of extensive SM&E networks. I argue that the implicit approach is potentially more powerful as it is more inclusive of both genders and interweaves the aspects of two traditionally opposite feminist strands.

This research also informs the theory of situated learning in that newcomer interactions are found to be a key aspect in legitimate peripheral participation and their actions should be understood to involve much more than knowledge circulation. The newcomer interactions, which are affective rather than strictly rational, play a significant role in the newcomers’ prospective full participation in the community of science.
CHAPTER 1

INTRODUCTION

Picturing Women’s Underrepresentation

The issue of women’s underrepresentation in science, mathematics, and engineering (SM&E) fields in the United States, in both education and the workforce, continues to be one of the main themes in current research. In spite of substantial gains since the 1960s, gaps still exist between women and men in terms of their college level enrollment in the SM&E majors. Women’s lower participation rates and differential treatment extends in SM&E areas beyond education. National reports highlighting these issues provide detailed descriptions and statistical figures about women’s disproportionate distribution and differential treatment in these fields (NSB, 2002; NSF, 2000, 2003).

Women are more likely than men to attend college or to enroll in college immediately after completing high school in the US (Rosser, 1995). In 1998, among those aged 25 to 29 who had completed high school, 68% of women and 63% of men completed some college. Similarly, in 1996, more than half (56%) of the undergraduate students at all institutions in the US were women (NSF, 2000). However, women continue to be underrepresented especially in engineering and computer sciences (NSB, 2002).

1 Throughout this document and my research overall, by the phrase underrepresentation of women in the SM&E fields I mean that in general, women are disadvantaged in their participation in the “natural sciences, mathematics, and engineering,” both in education and the workforce. In recent years the participation of women increased in SM&E, and in biology, women obtain more than half of the bachelor’s degrees (Figure 1-1). However women are still underrepresented in all fields in labor force (NSB, 2002; NSF, 2000). As the NSF reports use the term S&E to include all science and engineering fields (also social sciences and psychology), I use the above phrase in a generic sense.
The underrepresentation of women in SM&E fields extends beyond college and demonstrates itself as differences from their men counterparts in the areas of labor force such as salary, and academic rank and type of school of employment in educational institutions. “Women faculty earn less, are promoted less frequently to senior academic ranks, and publish less frequently than their male counterparts” (NSF, 2003, p. 1). For example, in 1997, more than half of all psychologists (63%) and sociologists (55%) were women, compared with 10% of physicists and 9% of engineers. Among full-time doctoral scientists and engineers in academia, 51% of men and 24% of women were full professors. Thirty-five percent of women academic scientists and engineers had tenure compared with 60% of men. The 1997 overall median salary (including both education and business occupations) for full-time women scientists and engineers was $47,000 compared with $58,000 for men; however, within occupations and within younger age categories the median salaries were found to be more alike (NSF, 2000).

Women’s retention in these fields is still a key issue at the college level. Despite at least two decades of attention to these issues, women are still less likely than men to choose a career that involves SM&E, and are more likely than men to earn bachelor's degrees in non-science and non-engineering fields (NSF, 2000). Among those that do choose a major in SM&E, the majority is still concentrated in certain fields such as biology, and also in the fields of psychology, and the social sciences (Figure 1-1). Why? Within the reform efforts in the US, the national initiatives often targeted K-12 education in terms of encouraging all students and especially girls (and other disadvantaged groups) to participate more actively in science education (NRC, 1996, 2000; NSF, 2003). With the teacher in the center, these initiatives included in-class interventions such as performing more hands-on activities, establishing collaborative/cooperative groups among students, making connections between the scientific content and the real world, and concentrating on problem-solving. Although the rationale underlying these efforts has been to enhance students’ interest in the sciences, these efforts were not as visible in higher education. The link between these enhancements from K-12 to college level

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2 I adhere to NSF’s definition of scientists and engineers, which is: “those who hold at least a bachelor’s degree in or are employed in the physical sciences; earth, atmospheric, and ocean sciences; agricultural sciences; biological sciences; mathematical sciences; computer sciences; social sciences; psychology; or engineering.” (NSF, 2000, p. xi)
education appears to be missing. Thus, what happens to girls as they enter college and afterwards often remains a mystery. What happens to girls after they enter college in terms of their interest and confidence in science and related majors? Can they transfer their interest from high school to college, and is that transformation smooth? Why are women still concentrated in certain fields? Are there initiatives similar to those in K-12, in college level education? Do the in-class interventions suffice? Or, is getting involved and interested in science a more complicated issue for girls? As these questions imply, it is time to turn our attention to science education at the college level and focus on the gender issues involved, as this research did.

Percentages of women earning bachelor's degrees in 1966, 1980, and 1998, by field

<table>
<thead>
<tr>
<th>Field of Study</th>
<th>1966</th>
<th>1980</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total S&amp;E</td>
<td>37.2%</td>
<td>48.7%</td>
<td>52.7%</td>
</tr>
<tr>
<td>Engineering</td>
<td>18.6%</td>
<td>9.4%</td>
<td>14.6%</td>
</tr>
<tr>
<td>Physical sciences</td>
<td>24.0%</td>
<td>23.8%</td>
<td>30.3%</td>
</tr>
<tr>
<td>Earth/atmospheric/ocean sciences</td>
<td>24.0%</td>
<td>25.0%</td>
<td>26.9%</td>
</tr>
<tr>
<td>Biological/agricultural sciences</td>
<td>39.2%</td>
<td>37.0%</td>
<td>39.1%</td>
</tr>
<tr>
<td>Computer science</td>
<td>39.2%</td>
<td>37.0%</td>
<td>42.3%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>46.8%</td>
<td>40.8%</td>
<td>63.3%</td>
</tr>
<tr>
<td>Psychology</td>
<td>74.4%</td>
<td>44.8%</td>
<td>52.5%</td>
</tr>
<tr>
<td>Social sciences</td>
<td>10.1%</td>
<td>7.9%</td>
<td>3.2%</td>
</tr>
</tbody>
</table>


*Figure 1-1.* Percentages of women earning bachelor's degrees.
Statement of Research Problem

As the statistical figures and the descriptions of the national reports show, the need for support and encouragement is obvious for women already in college intending to pursue a major in a SM&E field. Having upper-ranked women peers and women SM&E faculty (Seymour, 1995), and exposing women students to life stories of women scientists (Wygoda, 1993) might facilitate their retention, but are only a few among several strategies. Such a comprehensive network could be established through programs for women entering college and willing to pursue careers in SM&E fields.

However, according to Matyas (1992), few programs in the US are directly targeting undergraduate women students. Matyas reports that less than 10% of the over 300 programs identified targeting women compared with 51% targeting minority students. Moreover, various researchers evaluate those designed for undergraduate women in the SM&E majors including mentoring-only short-term programs (Packard, 2003) by using traditional quantitative methods, primarily consisting of comparing grades, grade point averages, and retention rates (Brainard & Carlin, 2001; Packard, 2003; Rosser, 1994, 1997), offering little insight in what is actually happening on the part of individual students. For example, none of the evaluations that I examined approached the science identities of women as sites of transformation, and what dynamics contributed to a possible transformation. Moreover, those evaluations did not give much emphasis to the feminist literature other than stating only liberal feminist goals of increasing the number of women in the SM&E fields. An explanation would be that evaluation projects often assess the effectiveness of the programs. Thus, they are descriptive in nature and address audiences including program directors, faculty and administrators, and funding agencies. Given their administrative roles, these audiences are mostly concerned about statistics and information about the effectiveness of the

3 By science identity I mean “the way the women students characterize themselves as full participants in the community of science.” Factors such as gender, race, ethnicity, socioeconomic status, history, and specific context play significant roles in PWISEM students’ science identity formation because it is “personal history, biography, gender, social class, race, and ethnicity” (Denzin & Lincoln, 2000, p.6) that shape an individual’s constructions/interpretations of a phenomenon, in this case, being a scientist.
programs. Eventually, the evaluation documents of these programs have little to say about linking theory with practice, and thus, are absent from the science education literature.

Besides adhering to some of the conventional evaluation methods, I aimed to fill this gap by employing the theory of situated learning/legitimate peripheral participation and the cultural-historical activity theory to understand the influence of the Program for Women In Science, Engineering, and Mathematics (PWSEM)\(^4\) at college level on women students’ science identities in depth. My purpose was to explore the dynamics that lead to possible transformation at the individual level. I believe that my research contributes to the literature on gender equity in higher education by adding the perspective of the programs designed for women, which have not received the full attention they ought to have.

**Research Questions**

The following were the research questions and their sub-questions that guided my research:

1. What are the interactions and contradictions that affect the science identity formation of the PWSEM students?
2. How do the PWSEM women identify themselves as future scientists?
   - Are they merely learning to fit themselves into the traditional community of science, or are they actively participating in reconstructing and transforming the social relations of scientific practice?
3. What is the social and cultural significance of programs such as PWSEM designed to enhance participation of women in SM&E fields at college level?
   - What are the key factors in such programs in motivating and supporting women students in their intended SM&E majors?

By addressing these research questions my main purpose was to shed light on the PWSEM’s influence on women’s participation in the community of science, and to what extent and in what way such a program might contribute to the resolution of the women’s

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\(^4\) *PWSEM* is a pseudonym that I use for this program throughout my writing and I often refer to it as the *Program.*
underrepresentation problem in science and science-related fields. It was also to
contribute to the science education literature concerning gender equity in higher
education and inform feminist theories as it related to women in science. The research
also provided opportunities for the PWISEM students to reflect on their experiences as
being involved in the SM&E fields; as a qualitative researcher, I tried to encourage them
to “gain control over their experiences” (Bogdan & Biklen, 1998, p. 38). I expect that my
research will also increase educators’ awareness of women’s issues in science and
science-related fields, and provide insight on aspects leading to more equitable science
education.  

5 I obtained the Human Subjects Committee approval for my research on August 19,
2003, just before the Fall 2003 semester started (see Appendix A). The Approval
Memorandum dated August 25, 2003, reflects a slight change I made in my research
protocol regarding the survey instrument. After one year, I submitted my request to
continue the project, and received the Reapproval Memorandum on September 13, 2004
(also in Appendix A).
CHAPTER 2

REVIEW OF THE LITERATURE

The History of Women’s Subordination

The statistical figures that I introduce in the previous chapter (Figure 1-1) point to the disproportionate distribution of women earning bachelor’s degrees in SM&E, and at the same time they tell us about an overall increasing trend in women’s participation, beginning from the late 1960s, when the presence of women -especially in the field of engineering- appears to be much lower than today. The window of 1966-1998 covered in the figure corresponds to the time span of Second-Wave Feminist Movement having its roots in the 1960s. One of the events initiating the second wave was Betty Friedan’s book “The Feminine Mystique” published in 1963. In her book, Friedan pointed to the dissatisfaction and loneliness many white, middle-class, educated women felt in their roles as housewives and mothers. She investigated “the problem that has no name” and called for the redefinition of the traditional gender roles (Friedan, 1997). Another event was the publication of Kate Millett’s book “Sexual Politics” in 1968 (Tobias, 1997). Millett also pointed to the traditional gender roles by arguing that “in terms of activity, sex role assigns domestic service and attendance upon infants to the female, the rest of human achievement, interest, and ambition to the male” (Millett, 1970, p. 26). Also known as Women’s Liberation Movement (Weedon, 1997, 2000), this feminist movement has made substantial contributions in making women’s voices heard since then until the current time, and through criticisms, opened the way to the Third-Wave Feminism emerging in the 1990s.

I found it crucial to introduce what women’s issues looked like prior to the emergence of the “picture” in Figure 1-1, and prior to First-Wave Feminist Movement originating in the 18th century and continuing until early 1960s (Barton, 1998). By going back in history, I also wanted to elaborate on the dynamics leading to the oppression of
women extending from pre-modern times. I believe that learning about the history of women’s oppression helps to illuminate women’s problems in present-day society. It is also important to know the historical context, which gave birth to the theorizing of various contemporary feminist perspectives, to better understand their implications for science and science education.

The discrimination of women and their being labeled as “inferior” to men has its roots in ancient times. The 19th century arguments of Western science equated gender difference to nature/biology and attached women’s “inferiority” to this difference (Schiebinger, 1989; Trecker, 2001; Weedon, 2000). As opposed to modern scientists claiming that sex determines gender (or “ascribed sexual character”), ancient scientists thought that gender (or “temperament”) determines sex (Schiebinger, 1989).

According to Schiebinger (1989), in the ancient times, biblical accounts of creation and the views of Aristotle and Galen were the two main perspectives on gendered issues. According to ancient scientists, “temperament (sexual or otherwise)” was determined by four elements (called humors), which at the same time were the four fundamental elements composing the universe: air (which is dry), water (which is wet), fire (which is hot), and earth (which is cold). In Aristotelian/Galenic view, women lacked heat compared to men, therefore were not able to expel their reproductive organs, as men had done. Since hot and dry things were considered as superior to those cold and wet, women were thought as “incomplete/imperfect” men. To prove that assertion, Galen, Pliny and others told stories of women converting to men because they had a peak point in their lives, which caused “extremely increased heat” in their bodies leading them to reach “perfectness.” On the other hand, Plato assigned the uterus “monsterness of nature.” These perspectives continued to dominate until late 16th century.

With the Renaissance, in the 17th century new ideas emerged, and well-known scientists like Descartes, Locke, and Leibniz did not talk much about “sexual temperament,” an issue often tackled by ancients. In a way, their silence made possible the formation of modern feminism, or the First-Wave, but at the same time it allowed the traditional (ancient) men dominance in science to continue. As it is well-known, liberal feminism based on “sameness” does not critique science but uses the scientific method as a tool to appropriate the claimed “deficit” notions of women (Barton, 1998; Rosser, 1997,
Shulman, 2001; Tobias, 1997; Weedon, 2000). The early feminists used the readily available “tools” at the time to “fight” against prejudices, and did not attempt to produce their own “tools.” For example, one of the early feminists was Marguerite Buffet, known for her defense of women by using logic and Christian theology, two doctrines used to subordinate women. Early feminists like Buffet expanded the Christian notion that “the soul has no sex” to “the mind has no sex,” going against the claim that women were less reasonable than men (Schiebinger, 1989).

Schiebinger (1989) points out that, in later years, going against Aristotle, Descartes indicated that reason, or the ability to use logic, was the same in all humans. For that reason, he was considered as a defender of women. According to Descartes, the only difference between sexes was their reproductive organs. Mind and body were separate, thus, the difference in the body would not generate a difference in the mind, or the reasoning capability. Locke, too, did not emphasize any differences between men and women other than reproductive organs, and argued that both genders need to get exactly the same education. Schiebinger implies that Descartes’ ideas are considered to have negative impacts in the long-term, because he disengaged the mind from the body, or the abstract and pure reason from the demands of everyday life, which later became the tenets of modern science.

In the late 18th century, sexual differences were no longer seen as remaining only in the reproductive organs. By the 1790s, European anatomists –almost all white men– pointed to the differences between female and male body, arguing that men were distinct in their physical and intellectual strength, and women were distinct in their motherhood skills. However, this difference was not solely a difference; it was arranged hierarchically, in favor of men.

The anatomists of the 18th century looked at the female and male skeletons to justify their theses, in other words, “scientific theories of difference were used to justify women’s exclusion from higher education and public life” (Weedon, 2000, p. 7). These scientists considered the skeleton as the most fundamental element in the human body. They looked for sexual differences in the skeleton, and if they could find, the sexual differences would no longer remain only in the sexual organs, but would penetrate every part of the body. Monro, professor of anatomy, was among the first to look at female
skeleton. He described female bones as incomplete, thus causing the female body to be incomplete and deviant, “measured” against the male body which was the standard. Thiroux d’Arconville, another anatomist (and a woman), drew the most “sexist” skeleton of female body (Schiebinger, 1989). The skull of the female skeleton she drew was smaller in proportion to the body than a male’s, the pelvic area was very broad, and the ribs were very narrow. According to Schiebinger, she might have used a woman as a model who had worn a corset throughout her life. The “feminine” details in her and other anatomists’ drawings were “knotted” to support social ideals of femininity and masculinity. Soemmerring was another anatomist who drew a similar female skeleton to Thiroux d’Arconville’s. His was criticized for the incorrect proportion of the ribs to the hips. Soemmerring’s rationale for such a proportion was “women’s less rigorous breathing because of their restricted life style.” Soemmerring is also known for his work on racial differences based on skeletons. According to him and some other scientists, like sex, race penetrated all of the human body beginning from the skeleton. By using pelvis and skull size as criteria, races and sexes were ranked hierarchically, with European male representing the fully developed human type.

By the 19th century, the sexist scientists delineated the differences and the inferiority of women in “clearer” ways. Barclay compared the female skeleton to an ostrich’s, and male skeleton to a horse’s. He also emphasized that a female’s skeleton more closely resembled that of a child’s. According to Trecker (2001), evolutionists of the 19th century claimed that women’s development had stopped at a lower stage of evolution, because of their sexual differences. In other words, in the 19th century, starting from biological sex and claiming objectivity, these scientists defined masculinity and femininity, and claimed that these, as well as race, determined social worth (Schiebinger, 1989; Trecker, 2001).

Rousseau’s theory of sexual complementarity, arising simultaneously with the gendered work of anatomists, claimed that women and men were different and complementary opposites. Thus, complementarians assigned women domestic duties in “private life,” and men, “public life,” establishing the sexual division of labor. These separate spheres set for women and men, were “equal” grounds where each sex would have a chance to fully demonstrate their natural capabilities. Yet they were constructed to
keep women away from entering “male-defined” fields. The theory of complementarity was an invisible guide of the 19th century doctors, scientists, and educators to “rework earlier theories about women’s rights and place, without realizing that the origin of their ideas lay not in their empirical data, but in their cultural heritage” (Trecker, 2001, p. 88).

The claims of “equality” of both complementarians and liberal feminists (or egalitarians) were in fact privileging men, or making that privilege explicit. Complementarians, although assigning the “private sphere” to women, indicated that women were free to enter public life. However, women had no civil rights, and it was complementarians who were in charge of setting the “rules.” Their fear was that equal education would masculinize women and keep them away from their domestic duties, such as child care (Schiebinger, 1989). Going even further, some conservative complementarian doctors claimed that working intellectually too much would draw blood and energy from women’s reproductive organs, thus damaging the reproductive system and preventing women to perform their “natural duties” being child birth and care. Others wondered if highly educated women would ever have children, and some speculated that in the future American men “would have to import wives” (Trecker, 2001, p. 91).

Egalitarians, on the other hand, by declaring equal rights with men, “implied that women must learn the skills of men, not that men needed to learn skills traditionally cultivated by women” (Schiebinger, 1989, p. 231) and simply premised equality upon “women abandoning their femininity and transforming themselves into men” (Schiebinger, 1989, p. 233).

By restricting women’s participation in the public sphere, in the 17th through 19th centuries, European men (and in some exceptional cases, European women like Thiroux d’Arconville), ensured the “masculinity” of these fields, and made (easy) sexist arguments without the input of women (Schiebinger, 1989). Doing science was “forbidden” to women and labeled “unfeminine,” thus pushing women to the “margins” of scientific knowledge (Eisenhart & Finkel, 1998); ironically, before science had become center of social power and intellectual focus, replacing theological and philosophical studies, theology and philosophy were the disciplines considered “unfeminine” and inappropriate for women. When science itself was heretical and had a lower prestige compared with classical knowledge, men encouraged women to be active
participants in science. Women wrote science books, textbooks, and scientific articles for journals. Midwifery and medicine were among the sciences mainly pursued by women, but that only lasted until their recognition as scientific professions in the industrial era (Schiebinger, 1989; Trecker, 2001). The process called the “reproduction of subordinate status” (Eisenhart & Finkel, 1998) served to keep women subordinate to men by means of culturally encouraging women to value and pursue “feminine” behaviors and fields of study. Power relations had been preserved.

Furthermore, as Schiebinger (1989) argues, in the 19th century science women’s voices were not silenced, they were not present, and “only in this context one can understand the urgency of the notion that women simply are incapable of science” (p. 235). These early ideological constructions and formulations of science originating from ancient prejudices “stated in the most modern and approved words” (Trecker, 2001, p. 96) have served as barriers to keep women away from the SM&E fields until the present day.

Strands of Feminist Theory

In feminist theory (in difference feminism in particular) gender is thought as socially constructed as opposed to sex which is biological, and that makes gender vulnerable to social and political re-definitions (Howes, 2002; Tobias, 1997). Throughout history gender has been defined and redefined, and certain tasks or qualifications have been associated with being man or woman. Since the First-Wave Feminist Movement in the 18th century, various theorizing of feminist perspectives led to the analysis and different explanations of women’s subordinate status. The First-Wave Feminist Movement was followed by the Second and Third waves, each building on one another and appropriating the previous. All of them were political in nature, and the politics of feminism challenged the existing power relationships between men and women in society (Weedon, 1997). Furthermore, Tobias (1997) argues that politics target the right to work, marriage and divorce, participation in the military, pornography, and even advertising, all of which affect how people see women and how women see themselves. On the other hand, the political and critical view of education points to the power relationships in education (Barton, 1998).
Having introduced the historical context, which gave birth to the theorizing of various contemporary feminist perspectives since the 18th century, in this section I elaborate on each of the strands. Feminist theories have their own theoretical underpinnings, and bring explanations and possible ways of changing the patriarchal structure (and ways of political action) (Weedon, 1997). I illustrate the tenets of each of the feminist theories, their theoretical underpinnings, and their implications for transforming science education, in particular. Although I describe each of the strands, I elaborate more deeply on the three of them: liberal feminism, radical feminism, and psychoanalytic feminism, which I include as components of my theoretical framework (discussed in Chapter 3). I structured this section in three parts following the historical sequence of the emergence of each of the waves: (1) First-Wave (sameness) feminism, (2) Second-Wave (difference) feminism, (3) Third-Wave feminism (Figure 2-1).

In the First-Wave (sameness) feminism part, I discuss liberal feminism. In the Second-Wave (difference) feminism part, I elaborate on Marxist feminism, first-wave socialist feminism, and second-wave socialist feminism, the three of which are closely related. As its name implies, first-wave socialist feminism is a First-Wave feminism strand, but I include it in the Second-Wave feminism part since it is tightly linked with Marxist feminism and second-wave socialist feminism. In the Third-Wave feminism part, I examine postmodernist and poststructuralist feminisms.

First-Wave (Sameness) Feminism

Liberal Feminism

A general definition of liberal feminism is the belief that society bars women from participating in science and other scientific organizations with external political and social forces (Barton, 1998; Howes, 2002; Schiebinger, 1989). These forces came into power especially when the industrial revolution dominated the society in the middle and late 18th century, and separated the public sphere from the private, the latter thought to be suited for women (Donovan, 2000; Tong, 1989). The main discriminatory idea that liberal feminists refused was the argument that women lacked rationality and that they were not qualified for citizenship or other domains than the private, proposed by famous liberal theorists like John Locke. Another argument that they denied had emerged with
the development of the scientific method by scientists like Machiavelli and Bacon. These scientists and others identified women with the resisting and irrational nature, which needed to be “controlled” (Donovan, 2000).

Figure 2-1. Feminist theories.
Liberal feminists seek no specific privileges for women but require the removal of the “barriers” and fixing the social and political forces that keep women out (Howes, 2002; Rosser, 1997). According to liberal feminists, everyone should receive equal opportunities without discrimination on the basis of sex (Rosser, 1997). The goal is to have sameness with men, and equality is essential (Scantlebury, 2002; Weedon, 2000), thus liberal feminists are also known as “rights-oriented” feminists (Tobias, 1997). Mary Astell and Mary Wollstonecraft are among the early liberal feminists (Weedon, 2000).

Tong (1989) distinguishes between the liberal feminists in terms of their approach to state intervention in the public sphere, namely, the family or domestic society. Accordingly, there are two different ideas proposed to underlie the state intervention, carried by classical (or libertarian) liberals and welfare (or egalitarian) liberals. For classical liberals, the state needs to protect the civil rights, such as property rights, voting rights, freedom of speech, freedom of religion, and freedom of association. It does not interfere with the free market, but simply provides each individual equal opportunity to participate in it. On the other hand, welfare liberals propose that the ideal state focuses on economic justice instead of civil liberties. The state needs to interfere with the free market by establishing legal services, school loans, low-cost housing, Medicare and such. In this sense welfare liberals seem to recognize women’s subjection as a class to men and the patriarchal structure of the society (Donovan, 2000). According to Tong (1989), many 19th-century liberal feminists are of the classical, or libertarian type and many 20th-century liberal feminists are of the welfare (or egalitarian) type. The latter seems to represent an intermediate flow to the second-wave feminism, which focuses on women’s difference instead of sameness (with men). As a matter of fact, egalitarians are more concerned with individual needs, and are more inclined to make legal interventions to the patriarchal structure, which is a notion associated with radical feminism in the late 1960s, and an idea in line with the recently emerging feminist standpoint epistemology.

Liberal feminism shares the two fundamental assumptions of the traditional scientific method (thus it is sometimes called “scientific feminism” (Schiebinger, 1989)): 1) Human beings are highly individualistic and obtain knowledge in a rational manner that may be separated from their social conditions, or context, 2) Positivism is the theory of knowledge (Rosser, 1997). According to these assumptions “rationality is placed in
binary opposition to the body” (Weedon, 2000, p. 13). Obtaining knowledge is both objective and value-free, which are essential components of the scientific method. Value neutrality means being free from values, interests, and emotions associated with a particular class, race, or sex. Thus, liberal feminists assume that women would do science the same way men do, and once barriers are removed and women in science are not being discriminated because of their sex, women would constitute 45% of scientists, because this is their proportion in the overall workforce population (Rosser, 1997). Also, the rationale behind claiming equal (science) education for both girls and boys is that both genders deserve to “develop their rational and moral capacities so that they can achieve personhood” (Tong, 1989, p. 15).

However, in past two decades since the emergence of Second-Wave Feminism, feminist historians and philosophers of science (Haraway, 1988; Harding, 2001), and feminist scientists (Fausto-Sterling, 2001; Hubbard, 2001) have pointed out that science is not value-free, and patriarchal bias does exist. Liberal feminists argue that once aware of bias, men and women scientists might design scientific projects which are value-free; it is possible to find a perspective from which to make rational and neutral observations. Lack of objectivity and presence of bias occur because of human failure to properly follow the scientific method, and by adding women scientists as a “corrective measure to make the scientific method function better” (p. 85) those biases would be eliminated (Rosser, 1997).

Liberal feminists assume that gender, or overall personality is not related with the biological sex, and thus women and men are equal. The single most important goal of women’s liberation is sexual equality, or freeing women from sexually stereotyped roles in the society, such as mothering, teaching, nursing, etc., and allowing them to enter other areas traditionally defined as masculine (Tong, 1989). One of the problems of assuming sameness with men and requiring no change in patriarchal structure was that women were expected -and “fixed”- to be like men (i.e., with no off time to have children) (Scantlebury, 2002; Schiebinger, 1989). Indeed, in contemporary society there are still arrangements that leave women two options, one is to remain in work, and the other is to remain fertile. For example, recently, a number of women employees in chemical and automotive industries in the US were forced to “submit to sterilization by hysterectomy”
in order to be employed in “prestigious” jobs; the underlying reason was that they were considered “potentially pregnant” (Hubbard, 2001, p. 155).

As the example above reflects, there are still regulations that simply ignore women’s difference. These regulations leave women behind in the race for power, prestige, and money, the goods valued in the society. Liberal feminists fail to recognize the difficulty to combine marriage (and reproduction) with a career unless there are some changes in the patriarchal structure. One of them, Betty Freidan, argues that it would not be difficult for a woman to be both wife and mother, and also worker, and she defined that woman as Superwoman in her book *The Feminine Mystique* (1963) (Tong, 1989). In Freidan’s view the Superwoman tries to be both the quintessential mother and wife: the *woman* who is slave to her husband and children, and the *man* who is slave to his boss; but this woman has no time for herself. Another problematic issue emerging from these arguments is that the traditional patriarchal structure is accepted as the norm and a goal which all individuals in the society should reach. A critique of liberal feminism questions that norm and further advocates that women should work toward a society in which men, as well, have time to spend with their families and friends, instead of just with their professional colleagues (Tong, 1989).

Other than the classical and egalitarian approaches to liberal feminism for establishing gender justice, according to Tong (1989), there is another recent argument which is more conceptual. The key concept proposed to avoid discrimination based on a person’s sex is that of the *androgynous* person (*andro* comes from the Greek word meaning male, and *gyn* comes from the Greek word meaning female) who is both masculine and feminine. The idea is to encourage and guide persons to exhibit both masculine and feminine traits and behaviors (traditionally defined stereotypical characteristics). Psychologist Sandra Bem also challenges the notion of the “sex-typed individual who typifies mental health” and proposes focusing on “more flexible sex-role self-concepts” (Bem, 1974). Bem also points out that the most successful/accomplished people register as highly androgynous on her personality scale (Tong, 1989). So, to achieve healthy society individuals need to be encouraged to be androgynous as opposed to masculine or feminine. This would also ensure that no gender injustice is done.
Second-Wave (Difference) Feminism

In contrast with sameness feminism, difference feminism stresses that women and men are different, and women should be given proper provision for the differing needs that they may have. Difference feminism includes radical, second-wave socialist, African American Womanist and Racial/Ethnic, essentialist, existentialist, and psychoanalytic feminisms, which I discuss below.

Radical Feminism

As its name implies, radical feminism is radical. According to radical feminists, society’s patriarchal structure and androcentricity are the main sources of women’s oppression and subordinate status (Scantlebury, 2002). Radical feminism rejects most of currently accepted ideas about scientific epistemology –what kinds of things can be known, who can be a knower, and how beliefs are legitimated as knowledge- and methodology. So, radical feminism does not have its basis in theories such as Marxism, positivism, or psychoanalysis, which are developed by men. It also rejects feminisms based on these theories developed by men, and argues that the theory of radical feminism must be developed by women and built on women’s experiences to correct patriarchal society. Radical feminists argue coming together for consciousness raising and developing knowledge in women-only environments (Rosser, 1997). Radical feminism such as Mary Daly and Susan Griffin attempt to redefine “true” womanliness in such environments away from the patriarchal structure and man-defined womanhood, and to challenge heterosexuality seen as source and institution of women’s oppression (Weedon, 1997).

Radical feminism can be very extreme. Its target of criticism consists of mainly two domains: one is reproduction and mothering, and the other is gender and sexuality (Tong, 1989). According to Tobias (1997), at times around 1970s, radical feminists attacked so strongly the “male-headed, wife subordinated family” that they hardly accepted married women in their political groups. “Zero-population” growth became a national concern. Furthermore, radical feminists proposed that housewives should be paid wages.
The rationale behind radical feminists’ attack of the family is that it is the main source of the oppression of women which keeps them in the “cage” of the private, domestic sphere. Especially, women’s oppression stems from the notion of biological motherhood, which has been institutionalized under patriarchy. Shulamith Firestone, a radical feminist, argues that if women have no longer to reproduce then they do not have to stay at home and can go out to the workplace. Then the roles of women and men would equate, and the need for the family as an economic unit would disappear. Firestone’s solution for the “zero-population” growth mentioned above is the use of reproductive technologies such as in vitro fertilization and embryo transfer (Donovan, 2000; Tong, 1989).

However, according to Tong (1989), not all radical feminists agree with Firestone. Among others, Mary O’Brien criticizes her strongly, and argues that depending on reproductive technologies such as in vitro fertilization for child bearing would empower men, who already are the masters of the technology realm. According to O’Brien, it means losing the “power of the mother,” which is not something that women should give up. Another criticism points to the fact that the use of reproductive technologies would create divisions among women and form classes like economically disadvantaged and economically advantaged women, childbegetters, childbearers, and childrearers.

Radical feminists like Kate Millett discuss how the sex/gender system is organized in patriarchal society so that women are kept out of the public realm. Millett (1970) argues that sex is political because it is the source of all power relationships. In these power relationships, men subordinate women. According to Tong (1989), as is indicated in radical feminism, patriarchy is men’s control of the public and private worlds. If women are to be liberated men’s control must be eliminated. “To eliminate male control, men and women have to eliminate gender—specifically, sexual status, role, and temperament— as it has been constructed under patriarchy” (Tong, 1989, p. 96). Thus, radical feminists question what is “feminine” and what is “masculine.” Although most claim that an androgynous person would be the ideal with no room for power relationships with respect to sex, some argue that the feminine traits/characteristics need to be emphasized over the masculine since they are more humane (Donovan, 2000). Similarly, Mary Daly elaborates on the traditionally defined feminine traits and attempts
to reinterpret certain concepts, such as “spinster” and “hag,” and give them more positive meanings (Tong, 1989). In a sense, Daly radically deconstructs the language and tries to construct a different reality, which is woman (Donovan, 2000).

Radical feminists also point that women’s bodies are used by men against women. Thus, pornography is often attacked by radical feminists since it is seen as a male tool of perpetuating men domination. Indeed, many argue that pornography is nothing more than the trade of women’s bodies for the sake of men’s pleasure. Relevantly, radical feminists show connections among pornography, prostitution, sexual harassment, rape, and woman battering. They point to pornographic media including some of the romance novels, soft-core magazines such as Playboy, hard-core magazines like Bondage, and films like Snuff or Swept Away as contents highlighting scenes of men torturing women, which depict “the sexually explicit subordination of women” (Tong, 1989, p. 117). Radical feminists argue that pornography causes violent behavior toward women because thought leads to action.

Unlike liberal feminists, most radical feminists question patriarchal structure with respect to heterosexual relations and, furthermore, see heterosexuality as a threat to themselves as women. According to radical feminism, sexuality needs to be reinterpreted and reconstructed, so that women’s oppression is eliminated. Thus, most radical feminists see lesbian sexuality as an appropriate paradigm for woman sexuality. For them, a woman needs to be lesbian in order to become a full feminist. They argue that being a lesbian is more than a personal choice and represents a rejection of patriarchal sexuality (Tong, 1989).

Lesbian separatist feminists, a radical feminist subgroup, argue separation from men and creating women-only environments within a larger patriarchal society. They emphasize living with only women (Rosser, 1997). Radical feminists like Daly encourage feminists not only “to withdraw from the institution of heterosexuality but from all patriarchal institutions: churches, schools, professional organizations, and the family” (Tong, 1989, p. 126).

A criticism of radical feminism points to the fact that describing all men as corrupt and all women as innocent is not appropriate and that it means ignoring and simplifying the individuality and the history of men and women (Tong, 1989). This type
of approach can be more closely identified with postmodern feminism, which rejects a notion of a universal truth regarding the needs of women. For example, black women reject a separatist position since they have been united with black men on issues of race (Donovan, 2000). Another criticism warns about overemphasizing essentialism in radical feminist theory which leads to the perpetuation of gendered stereotypes. Poststructuralist feminism seems to appropriate this aspect suggesting that any identity is fluid, including the sexual (Weedon, 1997).

*Psychoanalytic Feminism*

The underlying assumptions of psychoanalytic feminism are very similar to those of existentialist feminism. Derived from Freudian theory, psychoanalysis proposes that girls and boys develop contrasting gender roles because they experience their sexuality differently and deal differently with the stages of psychosexual development. Based on Freud’s view that anatomy is destiny, psychoanalytic theory assumes that biological sex leads to different ways for boys and girls to resolve the Oedipus and castration complexes that arise during the phallic stage of sexual development, which is completed in the first five years of life (Rosser, 1997; Weedon, 1997, 2000).

However, psychoanalytic feminists Nancy Chodorow, Luce Irigaray, and Hélène Cixous appropriate Freud’s theory and propose that it is the *pre*-Oedipal phase of psychosexual development (the time when the infant is in symbiotic relationship with the mother and there is no masculinity or femininity yet) that is very important in gender acquisition (Weedon, 1997). These feminist theorists point to this stage and argue that the source of the problem of men and women’s relations in the society is that women do all the mothering, and by witnessing that infants and children develop different and stereotyped ideas about both genders. They further contend that were men to do mothering as much as women do, boys and girls would grow up with same opinions about both genders. As it is called, dual parenting would break down the sexual division completely and both women and men would be equally comfortable in both the private and the public domain (Tong, 1989).

Like existentialism, psychoanalysis recognizes that gender construction is not biologically essential; in “normal” gender construction the biological sex of the child-
caretaker interaction differs depending on the sex of the child. However, psychoanalytic feminist theory is not strictly biologically deterministic and it proposes that “abnormal” sexuality may result when gender construction is opposite to or not in accordance with biological sex (Rosser, 1997). Psychoanalytic feminists reject biological determinism, and point to the importance of the cultural and experiential influences that shape women’s gender (Tong, 1989).

However, Chodorow approaches the question of why women would want to mother from a slightly different perspective. She finds both the “nature” and “nurture” theories unconvincing and argues that gender roles cannot be freely chosen because by the time a person is old enough to make decisions he/she has already been engendered, or acquired gender roles. In Tong’s (1989) analysis, “as Chodorow saw it, the desire to mother, like the desire to be feminine, is implanted in girls before they become women. Thus mothering has little to do with conscious choice and much to do with an unconscious desire to mother” (p. 154).

Gender differences resulting in men dominance can be due to the fact that in society women are the primary caretakers for most infants and children. Boys are pushed to be independent, distant, and autonomous from and by their women caretakers, while girls are permitted to be more dependent on their mothers or women caretakers (Rosser, 1997; Weedon, 1997). As a result, boys are more unlikely to be able to relate to others and their independence pushes them to the public (and capitalist) sphere while girls learn to value connection which is necessary for their future roles as wives and mothers in the private domain (Donovan, 2000; Tong, 1989). Additionally, since women are socialized to value connection, they may feel closer to women than men because of their primary caretakers being women (Rosser, 1997).

According to Tong (1989) what psychoanalytic feminism sheds light on is that “a woman must do more than fight for her rights as a citizen; she must also probe the depths of her psyche in order to exorcise the original primal father from it” (p. 172). The problem of women’s oppression is a complex phenomenon which definitely requires that multiple aspects are taken into account, one of which is the psychoanalytic theory.
Second-Wave Socialist Feminism

Marxist feminism, first-wave socialist feminism, and second-wave socialist feminism are all associated with and in fact, built on each other springing from the same ideology. Therefore, while primarily emphasizing the latest shift, the second-wave socialist feminism, I also discuss all three in this section of the feminist theories.

Early socialist feminism, or first-wave socialist feminism, is closely aligned with Marxist feminism. Marxist feminism strictly emphasizes class as women’s oppression and not gender. Thus, Marxist feminism is a First-Wave feminist strand, and it is based on the assumption that women are equal to men, unless there is a social class difference. So, in Marxist feminism, only bourgeois (liberal) or proletarian feminism can exist. A bourgeois woman scientist would produce scientific knowledge similar to that produced by a bourgeois man scientist, but that would be different from knowledge produced by a proletarian woman scientist (Rosser, 1997). Marxist feminists regard “women’s access to the labour market as central to their liberation from patriarchy” and tend to see this “as something which would follow naturally from a socialist revolution” (Weedon, 2000, p. 17).

Zillah Eisenstein, one of the second-wave socialist feminists, argues that first-wave socialist feminism equates women's oppression with their position in the economic class structure. According to her, working-class women experience exploitation; in other words, their labor is not paid in wages equal to the value of their work. Women are paid less than men even for doing the same work simply because they are women (Eisenstein, 2004). On the other hand, Eisenstein continues, second-wave socialist feminism has its roots in Marxist feminism, too, but is more critical of the capitalist system as a site of patriarchy. Second-wave socialist feminism is more concerned with the ways the patriarchal organization of traditional heterosexual families institutionalize sexual hierarchy between men and women. Since society defined women as mothers and wives, women are primarily responsible for the domestic labor of the home and child rearing. The reason for women’s exclusion from the marketplace as full-time, and for their being in a state of unpaid housewives or being hired at lower wages than men is that their primary responsibility is considered to be home and family (Eisenstein, 2004).
According to Rosser’s (1997) accounts, “[second-wave] socialist feminism places class and gender on equal ground as factors that determine the position or perspective of an individual in a society” (p. 86). Second-wave socialist feminism rejects individualism and positivism as approaches to knowledge. It is based on Marxist critiques of science and knowledge, which view all knowledge as socially constructed (Weedon, 1997). According to Marxism, knowledge, including scientific knowledge, cannot be individualistic, objective and value-free. It includes human purposes and values. The prevailing mode of production determines the form of knowledge. In the 20th century US, scientific knowledge reflects the interests of the dominant capitalistic class. As opposed to liberal feminists, second-wave social feminists argue the social construction of knowledge and reject the liberal feminist standpoint of the neutral, disinterested observer (Rosser, 1997). Weedon (2000) mentions Juliet Mitchell as being among the second-wave socialist feminist names.

Rosser (1997) suggests that second-wave social feminism provides a theoretical framework that helps to explain some of the problematic issues for women in science. Second-wave socialist feminism would suggest that some instances of differential treatment of women in financial aid situations provide an example of gender intersecting with class. For example, as I mentioned before, the 1997 overall median salary (including both education and business occupations) for full-time women scientists and engineers was $47,000 compared with $58,000 for men (NSF, 2000). In spite of such a disparity, still women entering these fields are more advantaged than their women counterparts entering traditionally “women-defined” fields since traditionally men-dominated fields are seen as more prestigious and associated with income higher than their woman-dominated counterparts.

*Essentialist and Existentialist Feminism*

According to Rosser (1997), essentialist feminism focuses on gender differences based on biology. Gender differences are expressed based on visuo-spatial and verbal ability, aggression and other behavior, and other physical and mental traits based on prenatal or pubertal hormone exposure. These difference claims are likely to have originated from the work of the 18th and 19th century sexist scientists who drew the skull
of the female skeleton as smaller in proportion to the body than a male’s, the pelvic area as broader, and the ribs as very narrow, a skeleton resembling that of a child’s overall. Also, social Darwinists interpret Freud’s (anatomy is destiny) psychoanalytic theory and Darwin’s theories such that there are innate differences between men and women. The 19th century essentialist feminists propose that women are inferior in some physical and mental aspects while superior in other aspects, such as morals. Among those are Antoniette Blackwell and Amy Tanner (Rosser, 1997). Some essentialist feminists basically accept the ideas of men essentialist scientists, beginning from Aristotle, which imply that women cannot do science as well as men, and that they are suitable for “domestic” work (Schiebinger, 1989).

Others celebrate women’s difference and argue that women’s nature is not something to be replaced but to be maintained, for the sake of both women and society (Tobias, 1997). In this case, there is a denial of hierarchies (superiority vs. inferiority) in terms of some personal characteristics proposed by essentialists. Moreover, some essentialists claim the virtue of some natural traits specific to women, and believe in their being more humane. For example, Gilligan’s (1982) research on women’s moral development and understanding of justice implies that “in the different voice of women lies the truth of an ethic of care, the tie between relationship and responsibility, and the origins of aggression in the failure of connection” (p. 173). Belenky, Clinchy, Goldberger, and Tarule (1986) also stress the importance of connection and its value in “women’s ways of knowing.” Both studies point to the empathy women enact while learning or relating to others, unlike men. According to Rosser (1997) these two studies may spring from essentialist feminist assumptions. Both of them imply innate differences that women and men have in terms of moral reasoning and learning.

Contrasting essentialist feminists, existentialists suggest that women’s “otherness” is caused by society’s interpretation of biological differences, and not by the biological differences themselves. The assumed different learning styles and abilities (such as visuo-spatial abilities) are based on differential treatment of boys and girls, especially at young ages (i.e., playing with dolls vs. playing video games). Girls are then implicitly forced to behave like “girls” and to act feminine. The only distinction with the essentialist feminist perspective is the assertion that the differences between women and men spring from
their upbringing and not from their nature (e.g., different hormones). First to propose this view was Simone de Beauvoir (Rosser, 1997).

**African American Womanist and Racial/Ethnic Feminism**

Like socialist feminism, African American/womanist or racial/ethnic feminism (also called “black feminism” (Tobias, 1997)) also rejects individualism and positivism as an approach to knowledge, and accepts social constructivism. It is based on the African American critique of a white and Western approach to knowledge. In addition to the rejection of objectivity and value neutrality associated with the positivist approach accepted by liberal feminism, African American approaches critique dichotomization of knowledge and that science is identified with the first half, and African American with the second half, of the following dichotomies: culture/nature, rational/emotional, objective/subjective, quantitative/qualitative, active/passive, focused/diffuse, independent/dependent, mind/body, self/others, knowing/being (Rosser, 1997).

Whereas Marxism views class as source of power, African American critiques view the source of power as race. According to the African American view science represents white and Western interests. According to African American/womanist feminism, the other feminisms born during women’s movement also meet white, Western women’s needs, but not those of African American women (Tobias, 1997; Weedon, 2000). African American women experience oppression due to their gender as well as race. According to African American feminists, scientific knowledge produced by African American women would be more similar to that produced by African American men than that of white women. So, race seems to be a primary oppression factor in their view, similar to Marxist feminists, who seem to prioritize class as an oppression factor as compared with gender. One of the African American feminists pointing to these issues is bell hooks (Weedon, 2000).

**Third-Wave Feminism**

**Postmodernist and Poststructuralist Feminism**

It is not an easy task to differentiate between postmodernist and poststructuralist feminisms since they share many principles in common. As Weedon (1997) points,
people often conflate poststructuralism with the much broader term postmodernism. Weedon (1997) sees poststructuralist feminism as “having mobilized the postmodern critique of the authority and status of science, truth, history, power, knowledge and subjectivity, bringing a transformative gender dimension to postmodern theory and developing new ways of understanding sexual difference” (p. 171).

In broad terms, postmodern feminism rejects the idea that as claimed, the various feminisms would address all women’s needs. As Rosser (1997) states, “postmodernism dissolves the universal subject, and postmodern feminism dissolves the possibility that women may speak in a unified voice or that they may be addressed universally” (p. 99), because factors such as race, class, nationality, and sexual orientation make women different from each other. In other words, postmodernism suggests that the criteria used to produce theories and to establish what is true, false, good, or bad, are not universal and objective. Rather, they are “internal to the structures of the discourses, and thus historical and subject to change” (Weedon, 1997, p. 172). While rejecting “essentializing theories,” postmodern feminists continue to use theory “strategically in the interests of understanding and transforming oppressive social relations” (Weedon, 1997, p. 178). Theories, for them, do not mean a universal truth or “reality” but a strategic status in the struggle for change.

In a sense, feminist theorists either produce their own metanarratives as alternatives to patriarchal structure (such as radical feminism), or take a rather different path to approach the issue. Poststructuralist feminists “have sought to deconstruct existing metanarratives and to develop new theoretical approaches which insist on historical and geographical specificity and no longer claim universal status” (p. 172). Instead of making generalizations while addressing women’s oppression, poststructuralist feminists argue for attending to women’s differences both within and between historical periods or cultures. They deny a fixed (gendered) “self” and view this self as being constructed through language articulated experience. Poststructuralist feminism draws on the work of Foucault, Derrida, and Kristeva (Weedon, 1997). Some of the theorists associated with this work include Jane Gallop, Elizabeth Grosz, and Judith Butler (Weedon, 2000).
Poststructuralist feminism deconstructs the notion of gender. As Weedon (1997) explains,

Feminist poststructuralist approaches deny the central humanist assumption that women or men have essential natures. They insist on the social construction of gender in discourse, a social construction which encompasses desire, the unconscious and conscious emotional life. Feminist poststructuralism refuses to fall back on general theories of the feminine psyche or biologically based definitions of femininity which locate its essence in processes such as motherhood or female sexuality. There can be no guarantee of the nature of women’s experience since, in so far as it is meaningful, this experience is discursively produced by the constitution of women as subjects within historically and socially specific discourses. This does not rule out the specificity of women’s experiences and their difference from those of men, since, under patriarchy, women have differential access to the discursive field which constitutes gender, gendered experience and gender relations of power in society. However, women’s subjectivity will always be open to the plurality of meaning, and the possibilities contained within this plurality will have different political implications. (p. 162)

Howes (2002) argues that through poststructuralism we need to recognize our positions in the world, which may help to keep ourselves honest and to “work consciously for change” (p. 28). According to Barton (1998), Third-Wave Feminism demands “self-reflexivity,” which is about being aware of one’s own positionality (personal history, biography, gender, class, ethnicity, etc. in a specific context and history) while making sense of the world or taking certain actions. Moreover, it should be a critical awareness of own values and beliefs that guides an individual’s experiences. The implications of these for science education would be to challenge science as a school subject and as a discipline and to challenge the roles of teachers and students with an awareness of positionality. Barton (1998) argues that “science teachers must see their
work within the larger contexts of culture and community, power and knowledge” (p. 17) and they need to make their students aware of these power relationships, as well. Relevantly, Barton (1998) strongly recommends empowering students by “creating space for students’ lived experiences” (p. 134) in teaching science.

Current Problems in Women’s Education

*How Women Become Marginalized*

With the light shed on the history of women’s subordination, the problems that women continue to face today, especially when they attempt to pursue studies or careers in the SM&E fields, gain more meaning. The fact that women are less likely to enter SM&E majors at college level than men is very closely related with women’s historically subordinated status. In a sense, women are “suffering” prolonged effects of alienation from these fields since the ancient times. The forces that keep women away from these disciplines originate from the 19th century (and earlier) conservative scientists’ insistent work of justifying cultural expectations from women, and the sexual division of labor. The “masculine” structure of science as a discipline (Lederman, 2003), established in the past primarily by not accepting women as participants, has its effects as an invisible “repelling” force from these fields (Nichols, Gilmer, Thompson, & Davis, 1998).

*In The Science Realm*

According to Weinburgh (1995), over the last 21 years boys have consistently held a more positive attitude toward science than girls; however, a positive attitude is found to be more necessary for girls to achieve high scores in science fields. In other words for girls, doing well in science is closely related with “liking” science. Another argument is that girls hold more positive attitudes toward biology than any other natural science (Vockell & Lobonc, 1981; Weinburgh, 1995). This can be explained by the fact that in the late 18th century with the rise of the theory of complementarity certain natural sciences were thought as “more appropriate” for women, and one of them was botany (Schiebinger, 1989).

As I demonstrate in Figure 1-1, overall, the percentage of women getting bachelor’s degrees in the natural sciences and engineering is lower than men. However,
this does not occur solely at college level; on the contrary, it is a slow and continuous process covering a long period of time. Women’s underparticipation in SM&E has its roots in previous experiences (social and familial), and in education, beginning from elementary school. Traditional factors, such as family background, parent and even teacher attitudes toward girls and science, and what they think girls’ roles in the society are compared with those of boys’, have directly or indirectly influenced girls' interest in mathematics and science related fields for years (DES, 1975; Kahle & Lakes, 1983). For example, some parents immediately dress their daughters in pink, and their sons in blue, they give their daughters Barbie dolls to play, and their sons, toy cars and construction sites. Often these parents encourage their sons and welcome them to take things apart, while they may blame their daughters for the same behavior. Among other factors are gender-biased illustrations in high school science textbooks (favoring men) (Bazler & Simonis, 1990), and the “feminine perspective” (Gilligan, 1982) of relationships and learning that is overlooked by teachers (Peltz, 1990) or faculty members at the college level.

Many young women become unwilling to pursue careers in SM&E during middle school or earlier. Kahle and Lakes (1983) point to the fewer number of science experiences for girls than for boys, which include “science observations, instrument skills, field trips, experimental tasks, and extracurricular activities” (p. 136). According to Kahle and Lakes teacher attitudes towards gendered issues is one of the major factors contributing to that, such as expectations geared towards a perspective that boys can do “more science” (and “better”) than girls. Kahle and Lakes (1983) relate such an attitude to the fact that most elementary teachers are women who themselves have a low confidence in teaching science, and thus may represent “bad” role models by projecting their own scientific attitudes onto girls. When boys and girls are paired for performing scientific experiments, teachers may also allow boys do the most of the work and girls watch. The gap between genders continues to widen in later years. Eventually, by age nine, although expressing interest, girls experience less science activities than boys; this continues through ages 13 and 17 and results in girls developing a very restricted view of science as dealing with medicine, pharmacology, or nutrition, and in not picturing themselves as future scientists (Kahle & Lakes, 1983; Peltz, 1990).
For example, Kahle and Lakes’ (1983) study reveals that by age 13, only 35.4% of girls had tried to fix something electrical and only 37.1% had tried to fix something mechanical, compared with 68.4% and 79.3% of boys, respectively. Similarly, in their study of elementary students in science classes Jones, Brader-Araje, Carboni, Carter, Rua, Banilower, and Hatch (2000) report that boys are significantly more likely to play and tinker with science materials and tools whereas girls are more likely to touch them and to follow the teacher’s directions in the science activities. Given that playing and tinkering with materials enhances scientific conceptual development, educators need to find ways of giving equal opportunities to both genders (Jones et al., 2000).

Another factor that contributes to women’s underparticipation in college level SM&E majors is that they do not take appropriate or enough number of courses in high school to enable them to enter these majors in college (Bohonak, 1995); however, Peng and Jaffe (1979) report that taking enough number of mathematics and science courses in high school is a very strong predictor of entering "male-dominated" fields, both for men and women. The restricted view of science that girls develop beginning from elementary school leads girls to arrive at conclusions such as science being “masculine,” which in turn discourages the girls from doing it. For example, girls (and boys) view biological/life sciences as being less masculine than physical sciences (Farenga & Joyce, 1999; Jones, Howe, & Rua, 2000; Vockell & Lobonc, 1981). Schiebinger (2001) suggests that physical sciences seem “cold” to women for a number of reasons. Physical sciences: 1) have a cultural image of being “hard” (and humanities and social sciences of being “soft”), 2) have an aggressive culture, 3) tie historically to the military, 4) include extensive use of abstract mathematics, 4) have an image of being part of “big science,” and 5) require large and capital-intensive equipment.

Vockell and Lobonc (1981) uncover another factor contributing to young women’s tendency to take fewer science and mathematics courses in high school. It is the women’s interactions with their men peers (which they call “social-interaction factor”). Vockell and Lobone (1981) argue that women students in same sex classes perceive physical sciences as less masculine than they do in coed classes because the women in coed classes experience interactions with men peers as involving comparison and competition. These interactions increase stereotyping in women students’ views. This
situation is especially very explicit in “masculine” science courses where women are a minority. Similarly, Seymour (1995) delineates the woman-man peer interactions at college level, and their impact on the women’s decisions to switch from the SM&E majors (I discuss Seymour’s study later).

In the Technology Realm

As I mentioned before, children and adolescents learn to be “boys” and “girls,” and to behave “accordingly.” This differentiation demonstrates itself in the image of various technologies, as well. According to Benston (1988), everyone interacts with technology but technology is gender-typed. The society considers certain machines as “suitable” for men –saws, trucks, wrenches, guns, and forklifts-, and certain machines as “suitable” for women –vacuum cleaners, typewriters, food processors. Even with computers, girls have very stereotyped expectations. The following quote from Kreinberg and Stage (1983) is an example of how a sixth grader responds to a question about how she imagines using computer when she becomes 30 years old:

When I am 30 I’ll have a computer that has long arms that can clean the house and cook meals. And another computer that has a little slot that money comes out to pay for groceries and stuff. (p. 251)

The “suitability/non-suitability” pattern predisposes boys more positively toward technical craft subjects and allows them to approach technology and science related fields more confidently; on the other hand girls believe that these are not their domains and “are treading on forbidden territory if they want to find about it” (Lloyd & Newell, 1985, p. 243). As early as the sixth grade, boys report more extracurricular experiences with tools such as batteries, electric toys, fuses, microscopes, and pulleys, while girls report more experiences with bread-making, knitting, sewing, and planting seeds (Jones et al., 2000). Later on, men repair cars, drive large trucks, operate cranes, use computers, do scientific experiments, etc. while women enter these “male domains” usually as exceptions (Benston, 1988). As a result, men have access to much more of the “truly” technological realm.
At College Level

Among young women who enter college planning to major in SM&E, many fail to receive the necessary social support and encouragement to remain and achieve in their chosen field. Retention in these fields is still a key issue at the college level. According to Seymour’s (1995) three-year ethnographic study, the science climate at college level is a challenging one, the first two years of which she names as the “weed-out system.” She describes “weed-out system” as an ongoing socialization process of primarily one group, white men, consisting of moral and intellectual challenge, aimed at testing the ability of young men to tolerate stress, pain, or humiliation with fortitude and self-control, and where the principle of “only the very best survive” (p. 460) operates. Much of the challenge that women students face is found to be related with faculty and men peer attitudes. Seymour (1995) draws our attention to the point of view that a feminine perspective of many young women -and some young men- requires that they develop good personal relationships with faculty, which is closely related with Gilligan’s (1982) work outlining women’s difference in relationships. Women expect support, care and advice, which they very often cannot find, and eventually think that they performed badly and should not continue in the SM&E major, regardless of how well they are actually doing. On the other hand, Seymour (1995) reports that “male peers advocate not taking faculty 'rejection' to heart” (p. 469).

Seymour (1995) highlights the following as underlying reasons for women to switch outside the SM&E realm: (1) They enter college with a lower “goal-orientedness” than men, often under the influence of family or teachers to pursue a SM&E major, have more of a tendency to change their mind, and experience more support in their decisions to switch, (2) Young women have negative experiences with science faculty, which mostly consist of in-class subtle messages and differential treatment signaling that women are not welcome in their majors, (3) Lack of or little “personal pedagogical relationship” with science faculty, or the “impersonality” factor, contribute much to women’s discouragement; failure to encourage is taken as discouragement by most women students, (4) Behavior of men peers and TAs, including “sexually suggestive remarks and jokes,” accusations of “being unnatural,” “inherently ugly,” “too busy with academic work to learn the arts of attractive self-presentation,” “having lost attractiveness
after entering the sciences,” and “being lesbian” (p. 453), lead women to try to make their appearance as plain and “neutral” as possible, and eventually to a decision to switch, (5) Unwillingness of men peers to share their “elite” status with women in these majors and dense competition for grades, contribute to the challenging climate, (6) Lack of network for support from senior women peers who know the “weed-out system” leaves the first-year inexperienced women students alone in their struggling.

The resolution of these struggles on the part of women students appears either as switching outside SM&E or making personal adjustments to the system with resulting psychological discomfort. On the part of the broader educational community, there are two possible alternative solutions to be implemented: (1) Educating young girls to survive in the SM&E culture (Seymour, 1995), (2) Making fundamental changes in the traditional SM&E pedagogy (Rosser, 1994, 1995, 1997; Seymour, 1995), which is outlined as follows:

Some aspects of the learning environments in which many women feel most comfortable – particularly those which are interactive, cooperative, experiential, and learner-focused- are also congenial to many young men… Moving pedagogy from a focus of teaching to a focus of learning, and from selecting for talent to nurturing it, will disproportionately increase the persistence rate of able women in SME majors. It also promises to reduce the loss of able male students (Seymour, 1995, p. 470).

While the first option implies that women students need to be educated to cope with the struggles that they would possibly encounter upon entering a men-dominated field, and leaves the issue of “masculine” science untouched and uncriticized, the second option offers taking a certain strategy, or standpoint, so that women challenge the traditional understandings of science and teaching science. The latter is in parallel with proposed educational reform since moving the focus of teaching to students and their learning means including diverse experiences and points of view, and making the learning of science more meaningful and authentic for everyone (NRC, 1996, 2000).
How to Change SM&E Pedagogy to Make it More Gender Inclusive

Feminist Critiques of Science

In her meta-analysis covering the literature between 1970 and 1991 of studies focused on gender differences in student attitudes toward science, Weinburgh (1995) reports that “although gender differences in attitudes have been recognized, nothing substantial has been done in 21 years to change attitudes in students, especially for girls” (p. 395). Although this argument overlooks the increasing trend of the participation of women in the SM&E fields in the last two decades, it has significant implications in that the focus has been on “changing the attitudes of students” but not on bringing the philosophy of science itself to the table. In recent years, feminist research has turned our attentions to the view that changing the SM&E pedagogy could be attempted in light of feminist standpoint epistemology. One of the strategies is to create more “woman-friendly” environments so that women students—as well as some men—can include their life experiences while critically analyzing science, and relate to science in a more meaningful way (Harding, 2001; Rosser, 1994, 1995, 1997, emphasis mine).

Feminist standpoint theorists question the notions of objectivity and value-neutrality in science and provide important implications for science education. These theorists argue that the doing and teaching of science reflects a “masculine” perspective which tends to exclude women. As well, Nichols et al. (1998) point to the subtle epistemological marginalization of women besides overt discrimination. In epistemological marginalization masculine ways of thinking are valued and more feminine approaches to natural phenomena, the relationship between the knower and the

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6 A document produced by the National Academy of Sciences also discusses research ethics and points to the fact that “values cannot— and should not— be separated from science” (NAS, 1995, p. 7). Rather, the authors argue that researchers need to acknowledge the suppositions and beliefs that may lie behind their research, but that they need to use that “self-knowledge to advance their work” (p. 8).

7 This critique is done most extensively for biology (Fausto-Sterling, 2001; Hubbard, 2001). However, Elizabeth Potter’s recent work demonstrates critiques about chemistry, too. In her book about Boyle’s Law of Gases Potter (2000) argues that “his [Boyle’s] work was not neutral among contextual values” and “both empirical and ideological considerations convinced Boyle to accept mechanistic principles” (p. 185).
known, and ways of knowing, are denied. Relevantly, Harding (2001) claims that there can be only a “weak objectivity” in science without the voices of those barred from doing it. So, to maximize objectivity and make it “strong” the voices of those having qualifiers other than being white, masculine, modern, heterosexual, and Western, need to be included in science. As long as science is representative of primarily one set of approaches, it cannot claim being objective or neutral of values. Without such an inclusion, it is not possible to even discuss the issue of bias or to question the proclaimed value-neutrality in science (Wyer, Barbercheck, Geisman, Örün-Öztürk, & Wayne, 2001)⁸.

Haraway (1988) also attacks the notions of objectivity and value-neutrality arguing that “feminists have to insist on a better account of the world” (p. 579) and that is “science.” According to Haraway (1998), feminist objectivity means situated knowledges, which implies recognizing that doing science and producing knowledge involve looking at phenomena from a certain perspective, without claiming “‘God tricks’ promising vision from everywhere and nowhere” (p. 584), referring to the proclaimed objectivity in science. However, Longino (2001) criticizes the feminist standpoint theorists for one thing, and it is because they propose that “the ideal epistemic agent is not an unconditioned subject but the subject conditioned by the social experiences of oppression” (p. 215). So, the feminist standpoint theorists see one position as superior to others, and in some ways this is just the same as what an objectivist mind has done. According to Longino (2001), it is important to include all points of view, not just those of the oppressed. Scientific knowledge “is constructed not by individuals but by an interactive dialogic community” (p. 219), and she calls this kind of objectivity “socially constituted objectivity” (p. 220). The dilemma that arises in this case, which is the dilemma of producing scientific knowledge through consensus, yet maintaining the socially constituted objectivity, can be avoided by detaching scientific knowledge from consensus and seeing science as “practice or set of practices” (p. 220). Also, the scientific knowledge must be seen as not “the static end point of inquiry but a cognitive or

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intellectual expression of an ongoing interaction with our natural and social environments” (p. 222).

Schiebinger (2001) approaches the feminist critiques of science from an all-encompassing perspective. She calls for appropriation of the feminist standpoint theory because in her view, there are problems with defining a “feminist science” in the sense that “terms such as cooperative, interactionist, holistic can mean different things to different people and in different historical contexts” (Schiebinger, 1999, p. 184). In a sense, she further develops Longino’s “socially constituted objectivity.” Schiebinger (2001) proposes the notion of “sustainable science” which questions the classical epistemology (how we know) of traditional science, and shifts the focus on the goals and outcomes of science (what we know and do not know, and why); in other words, she questions the values driving scientific research. According to Schiebinger, sustainable science is a broad notion including “responsibility toward nature as well as culture” (p. 474).

Sustainable science includes tools for gender analysis, which are “calibrated through race, ethnicity, age, class, sexual orientation, and geographies” (Schiebinger, 2001, p. 475). These are “analytics that have informed feminist revisions of science” (Schiebinger, 1999, p. 190) aimed to uncovering bias in scientific research. A number of these tools are to: (1) analyze priorities and outcomes, (2) analyze subjects chosen for study, (3) analyze institutional arrangements, (4) analyze the cultures of science and domesticity, (5) decode language and iconographic representation, (6) refurbish theoretical frames, and (7) reconsider definitions of science (Schiebinger, 1999). First of all, it is important to look at how scientists make choices about conducting scientific research and who benefits from it. Is it only political interests and funding decisions which underlie what will be known? Second, the subjects chosen for a study need to be representative of both genders, and if they are not, there is gender bias. Third, other than looking directly in the content of science, it is equally important to scrutinize the “relationship between the prestige of scientific institutions and women’s standing within those institutions” (Schiebinger, 1999, p. 188). Similarly, the values attached to different disciplines such as English and physics, and the hierarchies formed, require closer attention, which is analyzing the cultures of the sciences. Decoding language and
iconographic representation includes analyzing the metaphors and analogies used to construct scientific hypotheses because these “can determine the direction of scientific practice, the questions asked, the results obtained, and the interpretations deduced” (Schiebinger, 1999, p. 189). In gender analysis it is essential that questioning goes deeper and adapts a closer scrutiny to the theoretical frames, which may well reflect masculine values. Finally, what counts as science, who determines that and by what criteria, needs to be brought to table. By proposing these tools of gender analysis, Schiebinger (1999) argues that both getting women into science and changing knowledge through political and social reformulations would be possible.

**Feminist Critiques of Technology**

Women are even more underrepresented in the disciplines of computer science and engineering than in the physical, biological, and earth/atmospheric/ocean sciences. In 1998, the percentage of women earning bachelor’s degrees in computer sciences was 27%, and for engineering it was 19% (NSB, 2002). This can be attributed to the fact that computers and engineering are very closely identified with technology and its practices (Cajas, 2001). According to Faulkner (2001), the society associates the images of both science and technology with the masculine side of the “hard-soft” dichotomy of technology, thus preventing many girls from considering a career in engineering, a “hard” technology. Similarly, the reproduction of computing as a masculine field continues through the “micro-sociological relations of everyday life in schools, universities, and commerce” (Clegg, 2001, p. 317).

Like science, technology is not value-free; both reflect societal values and in fact, science, technology and society form a “seamless web” (Hughes, 1986). According to Berg and Lie (1995), both gender and technology are social constructs; technology is important in the social construction of gender, and gender is important in the social construction of technology. Pinch and Bijker refer to this as “interpretative flexibility” as opposed to a determinist view of technology (Berg & Lie, 1995; Faulkner, 2001; Wajcman, 2000). Interpretative flexibility refers to the different ways in which different groups of people dealing with technology can have very different understandings of it and its technical characteristics. “Thus users can radically alter the meanings and
deployment of technologies” (Wajcman, 2000, p. 450). As Hughes (1986) argues, technology may well represent social and political values, and the producers of technology can incorporate the preference of particular group of users in the design.

According to Lie (1995), technology reflects “the qualities of some social image of masculinity” (p. 382). Cockburn (1992, as cited in Faulkner, 2001) identifies seven ways that point to technology as a gendered field: (1) Key specialist actors in the design of new artifacts are predominantly men, (2) Gender divisions of labor in technology equate masculinity with technical skill, (3) Technological artifacts can be gendered, both materially and symbolically, (4) Cultural images of technology strongly relate with hegemonic masculinity, (5) The very detail of technical knowledge and practice is gendered in complex ways, (6) Styles of technical work may be gendered, and (7) Technology is an important element in the gender identity of men.

However, society recognizes not all technologies as masculine. Having said that, yet a dichotomy of “hard-soft” technologies implies a hegemonic relationship, a fixing of “ideal masculinity and femininity” (Clegg, 2001, p. 317). People consider industrial plants, space rockets, weapon systems as “hard” and real technologies, thus masculine, whereas they consider kitchen appliances, drugs, etc. as “soft” technologies (sometimes not even identified as technologies), thus feminine (Faulkner, 2001). Similarly, Wajcman (2000) argues that “women are hidden cheap labour force that produces technologies” (p. 453), often seen in positions of secretaries, cleaners, cooks, and are the main users of domestic and reproductive technologies (e.g. in vitro fertilization). Although the traditional image of technology as greasy machinery has changed to computing, gendered power relations remained the same. It is only the justifications of these relations that change from “machines being too heavy for women” to “the demand for intellectual skills for handling computers being too high” (Lie, 1995, p. 383).

The social images of technology that I expressed above contribute to women’s unwillingness and discouragement from participating in technology related fields. Volman and VanEck (2001) attribute the limited participation of girls in computing activities (beginning from elementary school) to negative attitudes, and the negative attitudes to the influence of social images, socialization at home and school, and the pedagogical and didactical characteristics of education itself. As a cure, some scholars
point to the importance of carefully designed activities for teaching science in technology enhanced classrooms in fostering gender inclusive education (Hakkarainen & Palonen, 2003; Mayer-Smith, Pedretti, & Woodrow, 2000). A proposition here would be that an interactive technology embedded in the course curriculum would involve women students as much as men in the science activities either because it would enhance interactions with the teacher and peers or because of the instant feedback factor; women value both of these more than men do (Belenky et al., 1986; Gilligan, 1982; Seymour, 1995).

Teaching Science in Gender Equitable Ways

Rosser’s “Female-Friendly” Model

In the frame of the “female-friendly” approach proposed by feminist standpoint theorists discussed before, Sue V. Rosser’s six-phase model of curriculum and pedagogy transformation aims to include women’s lived experiences in science teaching and learning at undergraduate level. According to Rosser (1995), this model should be considered “as a continuous spiral with overlapping components rather than as discrete stages” (p. 4) (Figure 2-2). Following is an explanation of these stages:

- **Phase 1**: Women’s underrepresentation in science and in its theoretical establishment and decision-making process is not noted. Many scientists claim that science is objective and not gender-biased. Most science curricula are in this phase.

- **Phase 2**: With recent reports on women’s underparticipation in science, most scientists have become aware that women are absent from science and are not included in the process of producing knowledge. Thus, they have begun to

![Figure 2-2. Sue V. Rosser’s “female-friendly” model.](image)

recognize that science and the teaching of science may reflect a masculine perspective.

- **Phase 3:** With the unfolding awareness in the previous phase, scientists and educators identify the barriers that prevent women from entering science, and discuss possible strategies to eliminate them.

- **Phase 4:** Faculty members initiate research of women scientists and shed light on the “lost names” (women scientists whose work had not been recognized in the science community). This documents that even despite the barriers “women can do excellent science.”

- **Phase 5:** This phase involves comparing the work of women and men scientists and searching the differences. Some differences are in the areas such as the distance between the subject and object in scientific study, and use of experimental subjects, and language. The next step is to investigate these differences and to explore possible biases and flaws arising from utilizing only a masculine perspective.

- **Phase 6:** Science is “redefined and reconstructed to include us all.” By including scientists from both genders and all races and classes will also appropriate the scientific method and will reduce bias. Science curriculum will be transformed and more diverse groups will be attracted to participate in science (Rosser, 1994, 1995).

  Rosser (1994) also suggests 17 strategies to help teachers and students move toward Phase 6. These strategies include discussing women scientists and their work (Wygoda, 1993), using “gender-neutral” language, including women subjects in experimental designs, encouraging uncovering other biases related with race, class, religion, and sexual orientation, using combination of qualitative and quantitative methods in data collection, and exploring problems of social concern.

**Encouragement at Early Ages**

Besides implementing “female-friendly” (Rosser, 1994, 1995) curriculum models at college level to encourage women students’ participation in the science and technology related fields, there are strategies to implement in earlier years. According to Kreinberg
and Stage (1983), girls and young women need to be encouraged in using technology and computers at early ages, beginning from elementary and middle school. This implies a great responsibility on the part of teachers, curriculum developers, science educators, school board members, teacher educators, and parents. In particular, Kreinberg and Stage (1983) offer four strategies for equality in computer technology: (1) Encouraging teachers to promote computer literacy for all students and to make sure the terminals are used by both girls and boys equally, (2) Convincing community organizations and science centers to create opportunities for girls to learn about computers, (3) Urging parents to use microcomputers and to teach their children how to do so, (4) Learning to use a computer ourselves and each of us teaching at least one girl or woman.

Similarly, a recent National Science Foundation report on girls in science and engineering (NSF, 2003) provides tips for parents and teachers for gender inclusive science and technology education. Tips for parents include encouraging their daughters to take things apart and put them together, engaging them in projects that develop spatial reasoning and analytical skills, creating computer area at home accessible to both their daughters and sons, communicating with their teachers and ensuring that teachers provide equal time for computer use, and talking about the mathematics and science courses necessary to enter one of the science, mathematics, engineering fields for future careers. Tips for teachers include connecting mathematics, science, and technology courses to the real world, using metaphors and examples meaningful for both girls and boys, ensuring that equal time is spent with computers by both genders, fostering an atmosphere of true collaboration, and brainstorming with students about all careers that use technology.

In summary, at early ages, the differences between the interest/ability of boys and girls in the SM&E fields could be reduced by considering all the social, cultural, educational, and attitudinal factors together. As well as boys, girls need to be encouraged to do and study science and technology. The responsibility is on the shoulders of parents, teachers, administrators, teacher educators, and everyone having a role in children’s and adolescents’ education.
Implications of the Feminist Standpoint Theory

Typically, the implication of the feminist standpoint theory for science education is to relate science to women’s everyday experiences so that it is authentic for them. An example of a feminist teaching strategy deriving from women’s lived experiences is that of Howes (2002). As a feminist biology teacher-researcher, Howes (2002) incorporates studies of prenatal testing in her genetics course. She emphasizes “listening” to her students’ ideas and experiences as her primary strategy of teaching. Moreover, she sees conversation not as a tool to teach science, but as “an end in itself,” which implies that science cannot be reflective of a certain set of approaches, but can be generated through the experiences of different individuals, and that needs listening and attention.

On the other hand, a newly emerging implication of the feminist standpoint theory for science education is teaching science by incorporating the perspectives of both genders. Roychoudhury, Tippins, and Nichols (1995) argue that embedding the feminist standpoint theory in (social) constructivism –“an intellectual tool that is useful in many educational contexts” (Tobin & Tippins, 1993, p. 20) - might ensure that the enacted pedagogical approaches of teachers “accommodate the needs of both genders” (p. 900). Similarly, Barton (1998) suggests that gender-inclusive science teaching could stem from social constructivist principles. As revealed through her feminist praxis while teaching chemistry at a community college, Barton (1998) further argues the “situatedness of science and science education” (p. 16), and identifies the “positional nature of knowing and being known” (p. 130). According to Barton (1998), teaching science is equitable only when students’ age, race, gender, social class, ethnicity, or history are important perspectives from which to look and explore the world; that is, she argues that the knower cannot be separated from the known. As part of her feminist teaching, Barton (1998) engages her students in oral history projects which involve interviewing “non-traditional” scientists about how science influenced their lives in personal and professional ways. These oral history conversations provide Barton and her students a language and space “in which to resist and refuse alienating practices of science” (p. 57), and an opportunity to redefine science and “to reposition their relationships with science” (p. 56). An attempt to impose a single set of values through science would alienate most students with
diverse backgrounds, thus it is important for educators to maintain the link between the knower and the known.

By employing Rosser’s (1994, 1995) female-friendly model, Roychoudhury et al. (1995) emphasize the importance of connecting women and men students’ everyday experiences with the learning of science, and the importance of giving them opportunities “to develop a sense of autonomy and control” (p. 918). To develop the sense of autonomy and control in students, it is essential that not all decision-making (including the decision of what is “female-friendly” and what is not) belongs to the teacher. While making decisions, it is important to attend to the different needs and interests of the different students. Irrespective of gender, the authors argue, college students positively perceive facilitation of personal interest. Besides facilitating personal interests, it is also essential that classroom experiences provide men the scope to be exposed to relational ways of knowing as women are learning the nonrelational ones (Roychoudhury et al., 1995).

Scantlebury (2002) suggests that student teaching practicum is a major area in which a feminist praxis can be enacted. She recognizes “the potential dangers… of enacting a feminist pedagogy” (p. 129) at least unless one has a “stable” position in an institution. As a teacher educator, Scantlebury (2002) challenges patriarchal structure by implementing feminist pedagogy in her courses, and encourages her preservice teachers to teach science in “gender-sensitive” ways. Bianchini, Johnston, Oram, and Cavazos’ (2003) study focusing on beginning science teachers’ teaching in “equitable and contemporary ways” (p. 419) suggests that exposing preservice teachers to courses on the nature of science helps to translate their knowledge into their classroom practices. Some of the teaching strategies the teachers in the study of Bianchini et al. (2003) utilize include illuminating women scientists’ lives and work (Rosser, 1994, 1995; Wygoda, 1993), initiating whole classroom discussion and groupwork, and overall, adjusting their teaching according to student needs, including both genders. In implementing equitable and contemporary ways of teaching, the teachers adopt a more student-centered approach, which is essential for the learning of all students (Bianchini et al., 2003; Howes, 2002; Seymour, 1995).
Scientists’ Views

At the college level where the teachers of science are usually the scientists themselves, negotiating contemporary and equitable ways of teaching may be more challenging since most college level science curricula are at the first stage of Rosser’s female-friendly model. In Phase 1, people do not note women’s underrepresentation in science and in its theoretical establishment and decision-making process (Rosser, 1994, 1995). A university in California attempted to establish communication between science faculty and women’s studies by developing the Promoting Women and Scientific Literacy project (Bianchini, Whitney, Breton, & Hilton-Brown, 2001). As a part of the project, the researchers investigated university scientists’ views on “inclusive science education.” The scientists who were interviewed approached equity issues from mainly three different perspectives: (1) All students are the same and should be treated equally with equal expectations, (2) Students belong to particular groups (i.e., women) and their needs should be addressed, (3) Students should be viewed as individuals and treated accordingly. However, the scientists also expressed lack of time and resources to implement gender inclusive teaching. Similarly, Lynch (2000), too, elaborates on lack of resources and points to that as a restrain to equitable science education. Bianchini et al. (2001) suggest that each of the three perspectives above need to be implemented simultaneously, professional developers and scientists should help each other to identify potential solutions, and time, resources constraints, and content issues need to receive institutional support.

Conclusion

Overall, in the literature of teaching science in gender inclusive and equitable ways, the main themes that emerge are: (1) Including women’s lived experiences only (feminist/woman-friendly science), (2) Including women’s and men’s lived experiences, (3) Including the experiences of both genders, of all races and classes, namely, everyone’s, (4) Teaching science in contextually and historically specific ways. There is a shift from a postmodern to a poststructuralist understanding that is apparent in these arguments, and in the feminist critiques of science. It is important (at the same time from a poststructural perspective) that either one of the strategies or a very specific view (to be
decided in the specific context and history) informs the practices and attempts of teaching science of teachers, educators, and other professionals, or encourages those on the margins to participate in science and related fields.
CHAPTER 3

METHODOLOGY

In this chapter I lay out my theoretical framework, describe the context of my research, present an overview of my research design, and elaborate on the research methods. Before introducing my theoretical framework I find it crucial to describe the context within which my research took place. Delineating the context is important because the contextual components are firmly involved—a both conceptually and linguistically—in the frame that I weave out of my theoretical thread.

Context of Research

The Program for Women In Science, Engineering, and Mathematics

My research took place in the context of a living-learning community established for encouraging college women students—especially first-year students—to participate in the SM&E majors. With an awareness of the national reports pointing to the underparticipation of women in these majors at college level, in 2001, a Southern teaching and research university in the US established this new undergraduate living-learning center based Program for Women In Science, Engineering, and Mathematics (PWISEM) to foster the participation of women in these fields, and enhance their retention.

Goals

The goal as stated in the Program’s brochure was to attract high quality women to the SM&E fields, especially to the more non-traditional areas of study such as physics, computer science, and engineering, and through the implementation of a variety of activities, to promote the students’ retention and success in the SM&E disciplines.
According to the Director\(^9\), Dr. Jones\(^{10}\), over the long-term the Program would promote the visibility and success of all women (faculty, staff, and students) who were engaged in the SM&E disciplines at the University. For example, the Director worked to get women faculty members recognized with named professorships and had the eligibility for nomination. Dr. Jones also argued that very simply by expanding the network of individuals involved in the Program the visibility and success of women would be enhanced. Eventually, the Program could become a general source of information on women in SM&E. Another long-term goal was to institute programs that would benefit the entire campus community as well as the local community. One example could be the establishment of community-service programs with local schools and other organizations to promote interest in SM&E among young girls (Dr. Jones, personal communication, June 13, 2003).

*Approach*

Students entered the Program primarily in their first year as undergraduates and lived together in the same on-campus residence hall. They could apply to the Program on-line through the University’s housing Web site. Additional information was available to the interested students in detail in the Program’s Web site.

All first-year students who were accepted to the PWISEM were required to stay in the residence hall. After their first year students who chose to live in another residence hall or off campus could remain part of the program until they completed their degrees; they had the opportunity to participate in the PWISEM activities as long as they were enrolled in one of the SM&E majors. Although PWISEM students were not required to

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\(^9\) The first and current Director of the program, Dr. Jones, is the recipient of the University’s 2001-2002 Distinguished Professor Award, the highest award the University bestows on a faculty member. This award, given in recognition of scholarly achievement, teaching, and service, reflects Dr. Jones’ long record of commitment to improving and increasing the participation of women in SM&E. An active contributor to national conferences and workshops designed to enhance the participation of women in SM&E, Dr. Jones also organized series of conferences for middle school girls held on the University campus (Dr. Jones, personal communication, June 13, 2003).

\(^{10}\) I have used pseudonyms throughout this document for this individual as well as the research participants.
live in the residence hall after the initial year, some space was available for returning students. Usually about five to ten upperclassmen preferred to continue in residence. These returning students had a responsibility to mentor their first-year peers, and were called “peer leaders.” All first-year PWISEM students were required to enroll in the Women in Science Colloquium, a one-credit course offered in the fall semesters. Also, to maintain residence in the hall and the program, participation in PWISEM activities was expected (PWISEM brochure, 2003).

A committee consisting of the Director, the PWISEM Student Advisory Board members, and Housing personnel ranked the applicants. The PWISEM Student Advisory Board included PWISEM students who were elected by their peers. Too, dedicated men and women scientists in the University served on the PWISEM Faculty Advisory Committee.

Other than accommodating a number of returning students each year, the Program accommodated 37 new students in the 2001-2002 academic year, 48 new students in the 2002-2003 academic year, and 35 new students in the 2003-2004 academic year. However, as the Director indicated, there was room to grow as the hall had space for 327 women. The University’s Housing Office was prepared to allocate more space in the residence hall to the PWISEM as demand grew. In the first year (2001) the acceptance rate to the Program was approximately 52%, in the second year (2002) it was 46%, and in 2003, it was 47% (Dr. Jones, personal communication, July 16, 2003). While deciding for the new students to be accepted in the Program, Dr. Jones received comments from the members of the Student Advisory Board. Some of the criteria that Dr. Jones and the students in the Student Advisory Board used in deciding were intention to pursue one of the SM&E majors, high SAT scores and having strong social skills.

*Events, Activities, and Opportunities*

Students participating in the living and learning community of the Program benefited from a variety of academic and social enrichments. The Program provided opportunities for women students and faculty in the SM&E fields to interact. Too, the program aimed to create a supportive environment that encouraged success, both through the interaction with faculty and continuous interaction with peers. The aim of this
community living unit was to provide support for women in these academic areas by offering role models, guest speakers, lectures, panel discussions, mentoring, advising assistance, research internships, tutoring and opportunities for field trips. The PWISEM students had opportunities for leadership experiences through participating in the Student Advisory Board, and access to support networks, both academic and professional, for women in SM&E majors. Another opportunity was tutoring. The PWISEM provided its students financial support for personal tutors from the departmental listings of the University.

Following is an overview of the Program’s events, activities and available opportunities since its establishment:

- Career panel discussions: In the academic year 2001-2002 (Year One of the Program) there were two career panel discussions in which women students found opportunities to talk and discuss issues with six selected women scientists. In the academic year 2002-2003 (Year Two of the Program) there was one career panel discussion in which the students talked with three selected women scientists from the medical field. For the academic year 2003-2004 (Year Three) there were not career panel discussions in the Program’s schedule.

- "Brown Bag" lunches: In Year One two "Brown Bag" lunches were organized to provide opportunities for the PWISEM students to meet women scientists, and exchange ideas on their careers and family life on a more informal basis. There were not any “Brown Bag” lunches in Year Two and Year Three.

- Special events: The Director presented a Year’s Homecoming Lecture, and organized a PWISEM End of Year Picnic in Year One.

- PWISEM socials: In Year Two, the Program included the following social events primarily to develop a sense of community among the PWISEM students: Ice Cream Social, “Clownin’ Around,” a luncheon with a meteorologist, and winter reception at the Director’s House. Similarly, in the beginning of Year Three, there was a social event, the Ropes course, on the University’s reservation. The purpose was to establish a sense of community among the new PWISEM students, and to foster their interactions with some of their upperclassmen peers in the Program.
The other social events in Year Three were the Ice Cream Social and the Winter Reception, each at the residence hall.

- Colloquium lectures: There were Colloquium lectures in the fall semesters each year with the exception of Year One. These lectures were part of the Women in Science Colloquium, a one-credit course required for the first-year students participating in the Program. In Year Two, various speakers in the SM&E fields and from other fields shared their experiences with the PWISEM students in the Fall 2002 semester. In general, the topics included scientific research, career opportunities, and academic advising, and there were 13 lectures in total. In Year Three, there were also 13 lectures in total, and the topics included scientific research, career opportunities, use of some of the technology resources of the University (a workshop\(^\text{11}\)), and academic advising. In the Spring semester of Year Three the Program had various speakers from the SM&E fields and other fields, as well. In contrast with the previous year, in Year Three, there were four field trips to the research facilities in the University instead of having Colloquium lectures these weeks. The students had five choices, and they chose four out of the five research facilities to visit. The students formed groups so that there was equal number of students in each group, and these groups visited each of the four facilities in turn.

- Field trips: In total, there were four field trips in the first two years of the Program, two in the first year, and two in the second year with the purpose of increasing the awareness of the PWISEM students about the SM&E in the real world, as well as about career opportunities in the SM&E fields. As I mentioned above, in Year Three, Dr. Jones assigned four of the Colloquium lectures to field trips to some of the research facilities of the University. There were other field trips proposed by the students for the spring semester of the same year.

- Internship opportunities: According to Dr. Jones, one of the many benefits for students participating in the PWISEM was the availability of paid internships for

\(^{11}\) The workshop was held with the PWISEM students divided in two sections. A PWISEM Faculty Advisory Committee member was responsible for one section, and I was responsible for the other section.
qualified students. These internships offered the students an opportunity to work with distinguished faculty, while gaining valuable laboratory experience. Four of the ten Year One PWISEM interns received regular placements in departmental laboratories for the Summer and Fall 2002 semesters as a result of their exemplary work during their internships in the Spring and Summer 2002. The spectrum of the internship fields spanned Biological Sciences, Meteorology, Oceanography, Neuroscience, Biochemistry, and Computer Science (Dr. Jones, personal communication, July, 2003). Similarly, in Year Two, two PWISEM students pursued paid internships arranged through the Program in Biological Sciences and Meteorology. In Year Three, seven PWISEM students participated in internships in the fields of Biological Sciences, Meteorology, Oceanography, and Medicine (the PWISEM Web site, retrieved on March 17, 2004).

- Award Ceremonies: In Year Two and Year Three, Dr. Jones organized awards ceremonies and honored 50 of the PWISEM students in total for their academic excellence. Some of these students received monetary awards, as well. Dr. Jones intended to organize these ceremonies each year, the purpose of which was to encourage the women students in their SM&E fields. She invited women scientists as special guest speakers for these events. For example, Dr. Sue Rosser, a zoologist and researcher on gender issues relating to science and engineering, also Dean of Georgia Institute of Technology was invited as the guest speaker of the awards ceremony in Year Three (Dr. Jones, personal communication, February 10, 2004).

Unlike the previous years, in Year Three the PWISEM students had bigger input in the selection of these events and activities. For example, during the Colloquium in the Fall 2003 the PWISEM students searched and voted for speakers they wanted to have in the next semester (Spring 2004), and for the places they wanted to visit. As well, the students were in charge of contacting and inviting the speakers, and also of scheduling their lectures. Having more events and activities in the spring semester, having the students’ input more extensively in the selection and arrangement of the events and activities, and organizing more field trips were all innovative strategies in the Program’s
approach in *Year Three* stemming primarily from the evaluation of the Program at the end of *Year Two* (for paper version of the evaluation report see Kahveci, 2004).

**Feminist Approaches Embedded in the Program**

The strands of the feminist theories that I discuss in Chapter 2 often inform the programs and projects designed for women. In her examination of 80 projects funded by the National Science Foundation under the Program for Women and Girls, Rosser (1997) reveals that each of these projects articulated (implicitly or explicitly) at least one feminist theory influencing the project’s approach. In her analysis, all of the projects state liberal feminist goals in terms of achieving equal access to science, but most of them share other aspects of other feminist theories such as existentialist or psychoanalytic feminism. Rosser (1997) argues that “although most projects include some aspects of more than one feminist theory, often a particular theory characterizes the core around which the project is organized” (p. 103).

In my preliminary analysis of the Program, which I describe more in detail in the Pilot Study in Chapter 4, I could identify some of the feminist approaches undergirding the Program. Of the nine strands of feminist theory I discussed, I found the three of them to be most closely aligned with the approach of the PWISEM: the Program involved primarily aspects of liberal feminism, and some of the aspects of radical feminism and psychoanalytic feminism.

As the Program’s brochure (2003) indicated the eventual goal of the Program was “to foster the participation and retention of female students in math, science and engineering fields” (p. 2). Through such an approach, over the long-term the Program aimed to “promote the visibility and success of all women (faculty, staff, and students) who are engaged in the SM&E disciplines at the University” (Dr. Jones, personal communication, July 2003). These statements and their underlying assumptions typified a liberal feminist project. As I discussed earlier, liberal feminists argue the removal of barriers to women’s participation in the SM&E fields, and the *equality* of women to men. Without critiquing the status quo of the patriarchal structure of the society, or the positivistic approach to scientific research, liberal feminists claim that once society
removes the external political barriers to women’s participation in these fields, women would do science the same way men do, and their success would be ensured.

On the other hand, one of the Program’s requirements was that the first-year students accepted to the Program lived together in an on-campus residence hall during the first year. The Program was part of a “living and learning community” and there was an emphasis on the development of the sense of community among its participants. Other than living together, the Director organized activities and events such as the PWISEM socials (Ice Cream Social, “Clownin’ Around,” winter reception at the Director’s House or in the residence hall, the Ropes course) with the purpose of enhancing the sense of community and fostering the interactions among the PWISEM students. All of these taken together, these components of the Program were reminiscent of the “women-only environment” proposed by radical feminists. As I discussed before, radical feminists argue coming together for consciousness raising and developing knowledge in women-only environments (Rosser, 1997). Although the Program’s approach involved this aspect of radical feminism, issues such as challenging the patriarchal structure and heterosexual relations in society as the sources of the oppression of women were out of its scope.

In my discussion of the psychoanalytic feminism, I mentioned that its underlying assumptions were very closely related with those of existentialist feminism because both suggested that the gender differences seen in terms of interest and/or confidence in certain areas such as SM&E aroused from the society’s interpretation of the biological sex. Relevantly, some parents raise and socialize their sons and daughters differently so that they fit the society’s view of sexually stereotyped roles. Eventually, boys have more experience in the science and technology realms as compared to girls (Benston, 1988; Kahle & Lakes, 1983; Lloyd & Newell, 1985). In a sense, the PWISEM aimed to compensate for this difference in experiences by organizing field trips, formal and informal meetings with scientists and engineers, and offering internship and tutoring opportunities to its participants. Psychoanalytic feminists attribute gender differences resulting in men dominance to women’s roles as primary caretakers for most infants and children. Their women caretakers encourage boys to be more independent from them, and encourage girls to be more dependent (Rosser, 1997; Weedon, 1997). Thus, since women learn to value connection through socialization, they may feel closer to women than to
men because their primary caretakers are women (Rosser, 1997). The fact that the PWISEM’s guest speakers (scientists, engineers), and staff (mentors, tutors, PWISEM Faculty Advisory Committee members) mostly consisted of women, and that the Program provided informal mediums for close relationships, as well, led to an assertion that the Program embodied a psychoanalytic feminist aspect.

Overall, my preliminary analysis of the Program allowed me to identify the embedded aspects of the three strands of feminist theory, liberal feminism, radical feminism, and psychoanalytic feminism, to some extent. However, as I include the feminist theories as a component of my theoretical framework which I describe next, I can examine the Program and its relation to the feminist approaches more closely.

Theoretical Framework

*Situated Learning: Legitimate Peripheral Participation*

Brickhouse (2001) suggests that feminist epistemologies and the learning theory of situated cognition may overlap. She argues that situated cognition “provides better resources for feminists than other accounts of learning” (p. 284) because it centers on identity-formation, which in turn, relates with gender. In addition, both feminist critics - such as Harding (2001) and Haraway (1988) - and situated cognition theorists point to the influence of context and the social position of the knower upon knowledge.

Lave and Wenger (1991) characterize learning as “legitimate peripheral participation in communities of practice” (p. 30). The meaning of this process is described by these theorists as follows:

By this we mean to draw attention to the point that learners inevitably participate in communities of practitioners and that the mastery of knowledge and skill requires newcomers to move toward full participation in the sociocultural practices of a community. “Legitimate peripheral participation” provides a way to speak about the relations between newcomers and old-timers, and about activities, identities, artifacts, and communities of knowledge and practice. It concerns the process by which newcomers become part of a community of practice. A person’s intentions
to learn are engaged and the meaning of learning is configured through the process of becoming a full participant in a sociocultural practice. This social process includes, indeed it subsumes, the learning of knowledgeable skills. (p. 29)

The term *legitimate* means having control over, or access to the resources of practice. As Driscoll (2000) puts it, for example, an ordinary Web surfer who happens to visit a university Web site does not have access the resources provided only to the students enrolled in the University. The term *peripheral* suggests that “there are multiple, varied, more- or less-engaged and –inclusive ways of being located in the fields of participation defined by a community” (Lave & Wenger, 1991, pp. 35-36). In Lave and Wenger’s view, “peripherality is also a positive term, whose most salient conceptual antonyms are unrelatedness or irrelevance to ongoing activity” (p. 37). So, peripherality has “attachment” and “involvement” inherent in its meaning.

However, peripherality also implies relations of power. It can be source of power or powerlessness. In a sense, it is a concept which can be “enabled” and “disabled.” If it is a place from where to move toward full participation, it is an “empowering position.” If it is a place where one is kept from participating more fully, it is a disempowering position. In the latter case, *interstitial communities of practice* may develop, which seek for ways to become full participants in the target community of practice (Lave & Wenger, 1991).

For decades, women have been barred or discouraged from participating fully in the communities of science. Besides explicit barriers, such as not accepting women to universities to pursue science in the 18th and 19th centuries (Schiebinger, 1989), implicit structures and practices of science have served to keep women away. As I indicated earlier, feminist critiques of science point to bias in scientific inquiry, referring to masculine values and needs (Fausto-Sterling, 2001; Haraway, 1988; Harding, 2001; Hubbard, 2001), and to hegemonic structures and practices within the community of science (Schiebinger, 1989; Seymour, 1995), which have served to keep women on the margins, or on the “peripheral trajectory of learning” (Wenger, 1998).
According to Davis (2001), interstitial communities of practice (ICPs) “provide a context – often from the margins of the primary community- where interruptions to legitimate practice can be addressed and/or removed” (p. 372). In her study Davis describes how a group of women claiming full participation in the community of science “deconstructed, challenged, disrupted, and reconstructed the traditional ways and practices of society and the science community” (p. 406) through their place in the “peripheral and subversive” ICP. However, I would argue that she failed to address how their efforts remained on the periphery within the boundaries of their ICP and did not challenge the larger traditional community of science. Davis (2001) points to the fact that groups in general and ICPs specifically (such as PWISEM) targeting women can be very effective in facilitating women’s legitimate participation in science. They can enhance interest, retention, and success in the SM&E fields, a liberal feminist goal.

In addressing the PWISEM in my research, I primarily looked through the lens of the theory of situated learning to better understand how the participating students learned to become scientists, mathematicians, or engineers, within the PWISEM as an ICP, and how they related to the broader scientific community. As Wenger (1998) indicates, learning as participation in communities of practice involves participating in more than one community of practice. The PWISEM students were simultaneous participants in the living-learning community of the PWISEM, and in the academic disciplines of science, mathematics, or engineering, as first-year students.

In the frame of my research, I also explored the “changing forms of participation and identity [of these women] who engage in sustained participation in a community of practice: from entrance as a newcomer, through becoming an old-timer with respect to new newcomers, to a point when those newcomers themselves become old-timers” (Lave & Wenger, 1991, p. 56, emphasis mine). I was aware that for such a change to occur a long period of time was needed; for example, the first two years at college might not be sufficient for a newcomer to become an old-timer. However, I believe that this research provided a meaningful “snapshot” uncovering the dynamics of the PWISEM and its influence on women students’ participation in the SM&E fields. It deeply explored the interactions and contradictions that affected the science identity formation of the PWISEM students.
By placing the Program in the center of my research and accepting it as my “reference ground,” I characterize “newcomers” as the first-year PWISEM students and “old-timers” as their upperclassmen peers, who are also participants in the Program. “Full participant” refers to the professionals (including women scientists) who engage in the activities organized by the PWISEM. The upperclassmen peers, also PWISEM participants, are relative old-timers with respect to newcomers, the first-year PWISEM students, but the old-timers are not full participants yet.

Specifically, I looked at how the dynamics of the program influenced the newcomers’ identification of themselves with science as women, and what these dynamics were. According to Lave and Wenger (1991), learning through legitimate peripheral participation is in the form of apprenticeships which are processes producing “knowledgeably skilled persons” (p. 62) and which involve apprentice-master and apprentice-peers relationships in their core. The theory implies that newcomers (or apprentices) acquire knowledge from the old-timers (or masters) to become skilled enough to talk the same “language” with them and to learn the culture of the community of practice so that they become full participants.

Although the goal of the PWISEM was in line with the approach of apprenticeships, because it aimed to ensure retention and success in the SM&E majors without challenging the status quo of the scientific community—a liberal feminist goal—, what happened within an individual student in the micro level was a more complicated phenomenon depending on her positionality (Barton, 1998). A student’s “personal history, biography, gender, social class, race, and ethnicity” (Denzin & Lincoln, 2000, p. 6) defined her positionality and these were the “axes” that shaped her constructions/interpretations of a phenomenon, such as being a (woman) scientist. Each student had her unique conceptualization of science and being a scientist, and the nature of her conceptualization depended on these axes, which determined her unique position in the world. To what extent she differed from or approached the mainstream characterizations was related with this position. Thus, this issue needed further and in-depth exploration. The historical and contextual specificity of each student and furthermore, the potential for transformation in their acquiring new science identities led
me to employ the cultural-historical activity theory as another lens in my research to look at what was happening at individual level and to go deeper in my investigations.

**Cultural-Historical Activity Theory**

The founders of the cultural-historical school of Russian psychology, L.S. Vygotsky, A.N. Leont’ev, and A.R. Luria, first initiated the theorizing of activity in the 1920s and 1930s (Engeström, Miettinen, & Punamäki, 1999). After its modification by Engeström in 1980s, its use became widespread especially in research dealing with technology implementation.

The idea of mediation has its roots in the work of Vygotsky, where tool systems (implying a specific human activity) and sign systems (language, writing, number systems) mediate through behavioral transformations to higher forms of individual development (Vygotsky, 1978). Leont'ev postulates three levels of a hierarchical activity system being operation, action, and activity, driven respectively by conditions, goals, and motives (Engeström, 1998, 1999) (Table 3-1).

<table>
<thead>
<tr>
<th>Level</th>
<th>Oriented towards</th>
<th>Carried out by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity</td>
<td>Object/Motive</td>
<td>Community</td>
</tr>
<tr>
<td>Action</td>
<td>Goal</td>
<td>Individual/group</td>
</tr>
<tr>
<td>Operation</td>
<td>Conditions</td>
<td>Routinized human/machine</td>
</tr>
</tbody>
</table>

Leont'ev expands on the triangulation developed by Vygotsky by conceptualizing the components of subject, mediating artifact, and object (Engeström, 1998) (Figure 3-1).
Figure 3-1. Vygotsky’s model of mediated action (left triangle) and its reformulation by Leont’ev (right triangle).

However, according to Engeström (1999), neither Vygotsky nor Leont’ev elaborates on "how the triangular model of action should be developed or extended in order to depict the structure of a collective activity system" (p. 25). By distinguishing between action and activity, Engeström (1999) expands on Leontev’s triangle. By contrasting the societal, historical, and collaborative nature of actions, he proposes the collective activity system (Figure 3-2).

Figure 3-2. Engeström's cultural-historical activity theory model.
In the model, the *subject* refers to the individual or sub-group whose agency is chosen as the point of view in the analysis. The *object* refers to the 'raw material' or 'problem space' at which the activity is directed and which is molded and transformed into *outcomes* with the help of physical and symbolic, external and internal mediating *instruments*, including both tools and signs. The *community* comprises multiple individuals and/or sub-groups who share the same general object and who construct themselves as distinct from other communities. The *division of labor* refers to both the horizontal division of tasks between the members of the community and to the vertical division of power and status. Finally the *rules* refer to the explicit and implicit regulations, norms and conventions that constrain actions and interactions within the activity system. (Engeström, 1998)

Engeström (1999) also distinguishes between *object* and *outcome*. He argues that the *object* is what connects the individual actions to the collective activity. However, the outcome is something which is not momentary and situational; it is broader than what individual actions would accomplish. So, individuals can have objects toward which they move with individual actions, but it is the outcome what is reached when there is a collective activity. According to Engeström (1999) outcome consists of “societally important new, objectified meanings and relatively lasting new patterns of interaction” (p. 31).

Cultural-historical activity theory represents a unit of analysis in the framework of "object-oriented, collective, and culturally mediated human activity, or activity system" (Engeström & Miettinen, 1999, p. 9). The internal contradictions, meaning "areas of conflict" in the system (either within or between the elements) are the *driving force* of change and development. Engeström (1999) argues that “any model for the future that does not address and eliminate those contradictions will eventually turn out to be nonexpansive” (pp. 34-35). A nonexpansive model tends to reproduce the status quo of the phenomena it represents, having no potential of advancement. Such a model feeds the
contradictions and eventually they become points of crisis instead of driving forces of change and development.

There are two continuously operating processes in the activity system: *Internalization* refers to “reproduction of culture,” and *externalization* means creating new artifacts for transformation. The two processes form an “expansive cycle,” which leads to transformation, equivalent to Vygotsky’s (1978) “zone of proximal development” at individual level (Engeström, 1999; Engeström et al., 1999). In other words, while the object and the outcome represent the milestones of the activity system, there is a gap between the two which needs to be bridged by transforming the system. This transformation occurs in the form of expansive cycle, which contains the processes of internalization and externalization. Engeström (1999) indicates that “the new activity structure does not emerge out of the blue; it requires reflective analysis of the existing activity structure –one must learn to know and understand what one wants to transcend” (p. 33). First, one internalizes this existing structure, then critical self-reflection takes place, and then a new structure develops -simultaneously reducing the contradictions-, which is externalization. This new structure is more sophisticated than the previous one and does not involve any of the contradictions present before; however, it has the potential to develop new contradictions. In this case, the processes of internalization and externalization may repeat and another expansive cycle may emerge. Furthermore, these may repeat numerous times, each time transforming the system to a more sophisticated level.

The notion of transformation is key in activity theory. Activity theorists criticize Lave and Wenger’s theory of legitimate peripheral transformation for its *temporal* dimension (Engeström & Miettinen, 1999) as following:

The theory of legitimate peripheral participation depicts learning and development primarily as a one-way movement from the periphery, occupied by novices, to the center, inhabited by experienced masters of the given practice. What seems to be missing is movement outward and in unexpected directions: questioning of authority, criticism, innovation,
initiation of change. Instability and inner contradictions are all but missing…” (p. 12)

Cultural-historical activity theory provides a comprehensive unit of analysis, which, in my research, is the PWISEM women students forming their science identities through participating in the PWISEM and in the larger scientific communities (Figure 3-3).

I determined the activity system components through conversations with individual students and looked for possible internalization or externalization processes resolving the contradictions, and leading to an expansive cycle or transformation of the system. The subject(s) of the activity system were the first-year PWISEM students (as subjects of my research), the communities involved the PWISEM, the community of the academic major the students’ pursue, the general community of science and other communities of social life, and the mediating artifacts included the dynamics of the PWISEM. For example, throughout my research I analyzed the PWISEM in terms of the various feminist theoretical perspectives, which were a component of the mediating artifacts. The object of women students in the PWISEM was “full participation in science” and the possible outcome was having “new” voices in the community of science, those which have not been given the chance to participate fully so far. This outcome could be only reached with the collective activity of the women students in the Program, and it was only possible with the interactions in the activity system (i.e. interactions with peers and faculty, living in a supportive environment, having mediating artifacts by means of the program), and the science identities that the students formed.

Visual Representation of My Theoretical Frame

Finally, by interweaving the theory of situated learning/legitimate peripheral participation (at macro level) and the cultural-historical activity theory (at micro level) discussed above, as the theoretical framework of my research, I constructed the notion of “activity systems on the periphery,” and the schema in Figure 3-4.
The large oval represents the community of science, with the most intense participation occurring in the center. The full participants, or the scientists, are in the center, represented as circles. The squares refer to the old-timers, who have learned the “language” and the “culture” of science, and are thus close to being full participants. The newcomers are on the periphery, represented as triangles. The smaller oval shape refers to the PWISEM as an ICP, and encloses its participants, both old-timers and newcomers. Old-timers can go closer to the center, but the newcomers cannot yet.

Through interaction with the old-timers, or their upperclassmen peers, and the full participants engaged in the PWISEM, the first-year PWISEM students aimed to become old-timers, and then, full participants in the community of science. I explored how this
happened and what happened at individual level through my analysis of the PWISEM newcomers by using the cultural-historical activity theory lens.

*Figure 3-4. Activity systems on the periphery: theoretical framework.*

**Research Design**

In my research, I employed a combined research design, including both the quantitative and the qualitative approach. Specifically, I used the “dominant-less dominant design” (pp. 177-184), one of the combined design models that Creswell (1994) proposes. In the dominant-less dominant design, the researcher conducts the research
primarily in the frame of one of the approaches, with a small component of the other. The dominant approach of my research was the qualitative paradigm, while the less dominant approach was the quantitative paradigm.

**Qualitative Approach – Dominant**

In spite of the various qualitative traditions that different researchers adhere, the essence of qualitative research includes some common “rules of thumb” agreed on by most researchers of sociology, anthropology, and education. These are: (1) looking for meaning and participant perspectives, (2) looking for relationships regarding the structure, occurrence, and distribution of events over time, and (3) looking for points of tension (Janesick, 2000). The qualitative approach embedded in my research drew on the *symbolic interactionist* tradition, which is compatible with phenomenological perspective and assumes that human experience is mediated by interpretation (Blumer, 1969, as cited in Bogdan & Biklen, 1998). Interactions are the foci of a research with symbolic interactionist perspective because individuals are seen in relation with the social group, and it is the interactions which make the crucial link between the two. Investigating not only the participants’ points of view but also how and by which processes these views develop, are also essential in symbolic interactionist tradition (Jacob, 1987).

In attempting to understand the PWISEM students’ interpretation of science and being a scientist, I paid attention to the mediating artifacts and the interactions that were present in the particular contexts of the PWISEM and the University, and how the students interpreted them and gave meaning. Another aspect of the symbolic interactionist approach is that *self* is constructed through interacting with others (Bogdan & Biklen, 1998), and that “groups develop shared meanings” (Jacob, 1987, p. 35). In this sense, my exploration of processes of science identity formation was primarily based on the ways the newcomers interacted with the other newcomers, the old-timers and full participants (from a situated learning perspective). The form of interpretation of being scientist tied to the internalization or externalization processes embedded in the cultural-historical activity theory.
Quantitative Approach - Less-Dominant

As I indicated above, I primarily depended on the qualitative paradigm to explore the science identity formation of the first-year PWISEM students within the context of the Program. However, I also used a survey instrument (the discussion of the instrument is in the Methods of Data Collection section) to gather data from the whole PWISEM first-year student population, which consisted of 35 students in the academic year 2003-2004, and a comparison group from the general university first-year student population, which consisted of the 63 Honors General Chemistry (HGC) students, for “descriptive, explanatory, and exploratory purposes” (Babbie, 1998, p. 256). Overall, I employed the instrument in my research in the form of pretest and posttest, the former of which I conducted in my pilot study (discussed in Chapter 4).

The quantitative part of my research represents the “static-group pretest-posttest design,” indicated as one of the weak experimental designs (Fraenkel & Wallen, 2003, p. 273), and in which two already existing groups are used. In such a design, the two groups are given a pretest, one receives a treatment, and then both groups are given a posttest. The change in students is analyzed and compared with respect to the variables of interest. With this design, I compared the PWISEM students with the HGC students over one academic year period, which was the 2003-2004 academic year.

The independent variable in my research was academic program, with two categories. One was the PWISEM and the other was the Honors Program, in which the comparison group students participated. The Honors students were different from the general university freshman student population in the sense that they were high-achieving students as determined by their SAT scores and high school GPAs, like the PWISEM students. The Honors students were thus eligible for enrollment in Honors courses, and upon the completion of the program, to receive the University Honor Medallion. High achievement was a common characteristic which they shared with the PWISEM students, and that made them a good comparison group, controlling for the variable achievement. Another common characteristic of the Honors students enrolled in the HGC course was that they intended to pursue a SM&E major as their PWISEM counterparts. The PWISEM students were different than the Honors students mainly in the sense that they were the group receiving the treatment. The treatment, which was the focus of my
research, consisted of the events, activities, and opportunities involved in the PWISEM to enhance women students’ participation and retention in the SM&E majors (explained in the *Context of Research*). These components exemplified complex interactions and I embedded them as part of my theoretical framework.

The dependent variables (or what is affected by the independent variable (Trochim, 2000)) I investigated with the survey instrument were: (1) interest, (2) confidence, and (3) determination in pursuing one of the SM&E majors (CIRP, 2000), (4) views on science and scientists (NORC, 2004), (5) interest in and (6) understanding of science and technology (NORC, 2004), and (7) psychological sex-role stereotyping/androgyny as measured by the Bem Sex Role Inventory (BSRI) (Bem, 1974). Because the HGC student group involved men students, that allowed me to make cross-comparisons among groups with respect to gender.

**Research Participants**

**Interview Participants**

The selection process of interviewees for my research occurred during the pilot study (summarized in *Methods of Data Collection* section and available in Chapter 4). I employed a strict *purposive sampling* (Fraenkel & Wallen, 2003) approach to determine the interview participants of my research, with whom I communicated for data collection throughout the research. I had two main criteria in mind while selecting the participants who were going to be involved in interviews. I wanted to have participants: (1) from different (intended) majors within the SM&E realm, and (2) from different ethnic backgrounds, in order to have a range of perspectives from which to understand the phenomena, the PWISEM. Of course, they needed to be volunteers, too.

As a first step, I examined the PWISEM pretests, and then recorded the names and the (intended) majors of the students. As a second step, I looked at the students’ homepages they had constructed during the technology workshop. These homepages served as another data source; they can be classified under *documents*, and more specifically, *personal documents*, which researchers use as supplemental information in case studies (to be mentioned later) in which main data sources are participant observation and interviewing (Bogdan & Biklen, 1998). At first, I considered eight
students, from among which I planned to select at most four. I restricted the number of participants in order to allow for intensive study. As a third step, I contacted the eight students via electronic mail and made appointments with each of them separately for short informal conversations. Because I was already familiar with most of the students gaining access did not constitute a problem.

To document our meetings, I prepared a one-page form (Appendix B) to be completed by each of the students basically asking for demographic information. I also placed three short-answer, open-ended questions about their experiences in the PWISEM and at the University. For me, the most important part in the form was the last question asking about their agreement to voluntarily participate in the interviews that I was planning to conduct. Even though all of them agreed to be interviewed, eventually, I decided to have the following four participants, shown in Table 3-2, as cases in my research:

Table 3-2. Interview participants

<table>
<thead>
<tr>
<th>Participants</th>
<th>(Intended) Majors</th>
<th>Ethnicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carol</td>
<td>Environmental Engineering</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Debbie</td>
<td>Nursing</td>
<td>African-American</td>
</tr>
<tr>
<td>Lena</td>
<td>Civil Engineering</td>
<td>White</td>
</tr>
<tr>
<td>Reyna</td>
<td>Biology</td>
<td>Caucasian</td>
</tr>
</tbody>
</table>

I should note that an interesting aspect with Debbie (as it came out from my interview with her) was that she was sophomore regarding her status in the University but joined the PWISEM in the academic year 2003-2004, so at the same time she was a first-year PWISEM student. Having this in mind, at that point, my intention was to continue to
have these four students as my research participants/cases, and to conduct follow-up interviews with them.

Although the cases had commonality with each other in terms of the phenomenon being studied (all of them participated in the same PWISEM events), each was likely to be particular and unique (Denzin & Lincoln, 2000) with respect to their intended majors, ethnicity and other characteristics. This ensured looking at the phenomenon from different angles. In this sense these cases embodied balance and variety, which is an important criterion in selecting cases (Stake, 2000). As Stake also indicates, I assume that readers (with various backgrounds) will be able to subjectively generalize from the cases in this research to their own personal experiences, and this is one of the quality criteria, transferability, that Guba and Lincoln (1989) propose for qualitative research (I explain the quality criteria in a subsequent portion of this document).

However, Stake (2000) also points that balance and variety are important but “opportunity to learn is of primary importance” (p. 447) and that the “potential for learning is a different and sometimes superior criterion to representativeness” (p. 446). I felt that I could learn from these four cases the most. As I reflected on the purposive sampling procedure that I employed, I recognize a criterion, being talkative, that I instinctively utilized during our short informal conversations to select these four students. Nevertheless, considering the opportunity to learn, it was wise to reconsider the cases during data collection if any limitations of access -such as schedule conflicts- emerged with the four cases that I delineated above. That was exactly what happened; I withdrew Debbie from the research after several unsuccessful attempts to contact her in the summer of 2004.

Survey Participants

Within the quantitative approach of my research design, I compared the PWISEM first-year student group with the HGC student group to better understand the impact of the PWISEM, as I explained earlier. Following is a closer look into these two groups in terms of student demographics, as revealed by the pretest.

In the academic year 2003-2004 there were 35 first-year PWISEM students (including one sophomore but first-year PWISEM student) accepted in the Program and
living together in the residence hall. The students were of various ethnic backgrounds, including Hispanics, African-American, Whites, Caucasians, and one Asian-American. Their ages ranged from 18 to 19, which is a typical age range for freshmen students. In Table 3-3, I summarized their intended majors as self-reported in the PWISEM pretest.

The most interesting figure was the relatively high number of students (10) intending to pursue a Biology major, which is the only natural science major with more women students than men. The other figure was the single student willing to pursue a major in Computer Science, a traditionally men-defined field. Both reflected the pattern of women students’ participation in the SM&E majors at the national level.

The HGC students had an age range of 17 through 21, but most of them were 18 years old, which is a typical age for freshmen students. In Table 3-4, I presented the majors the 63 HGC students intended to pursue at that time, classified by their gender, as self-reported in the HGC pretest.

Table 3-3. Frequency distribution of intended majors for the PWISEM students

<table>
<thead>
<tr>
<th>Intended Majors</th>
<th>Frequency (Number of Students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>10</td>
</tr>
<tr>
<td>Nursing</td>
<td>4</td>
</tr>
<tr>
<td>Engineering (undecided)</td>
<td>3</td>
</tr>
<tr>
<td>Exercise Science</td>
<td>3</td>
</tr>
<tr>
<td>Meteorology</td>
<td>3</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>2</td>
</tr>
<tr>
<td>Physics</td>
<td>2</td>
</tr>
<tr>
<td>Athletic Training / Sports Medicine</td>
<td>1</td>
</tr>
<tr>
<td>Chemistry</td>
<td>1</td>
</tr>
<tr>
<td>Computer Science</td>
<td>1</td>
</tr>
<tr>
<td>Science (undecided)</td>
<td>1</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>35</strong></td>
</tr>
</tbody>
</table>

Source: PWISEM Pretest, 2003
Table 3-4. *Frequency distribution of intended majors for the HGC students by gender*

<table>
<thead>
<tr>
<th>Intended Majors</th>
<th>Men</th>
<th>Women</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>8</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>Nursing</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Exercise Science</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Chemistry</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Physics</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Engineering (undecided)</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Undecided</td>
<td>7</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>34</strong></td>
<td><strong>29</strong></td>
<td><strong>63</strong></td>
</tr>
</tbody>
</table>

Source: HGC Pretest, 2003

I chose the HGC students as comparison group for three reasons: 1) According to the University policy, all natural sciences and engineering students were required to take at least the first course of freshman chemistry (the University Web site, 2003), so the students in this course represented a variety of majors in science and engineering similar to the PWISEM students, 2) Both HGC students and PWISEM students were “high-achieving” students with high SAT scores, 3) Relative ease of accessing and tracking the honors chemistry students over time as compared to another group from the general university first-year student population (usually, at least half of the honors students take the second part of the course in the second semester of the academic year).
Methods of Data Collection

Pilot Study - Summary

According to Jacob (1987), especially in qualitative research with symbolic interactionist perspective the research design emerges continuously, with preliminary analysis informing future data collection. Elsewhere referred to as “stretching exercises” (Janesick, 2000), pilot study is an essential component of qualitative research and researchers often do some background work prior to writing their proposals (Bogdan & Biklen, 1998; Janesick, 2000). Although typically proposals for qualitative studies are shorter than those of quantitative studies because the researchers do not know exactly what they will do, pilot studies allow them to develop more detailed plans about their research (Bogdan & Biklen, 1998). These stretching exercises provide the researchers opportunities “to practice interview, observation, writing, reflection, and artistic skills to refine their research instruments, which are the researchers themselves” and “to begin to develop and solidify rapport with participants as well as to establish effective communication patterns” (Janesick, 2000, pp. 386-387).

In light of these assertions I conducted a pilot study as an integral part of my research. Here I summarize the background work that I did in the field of the PWISEM, and a broader discussion of the Pilot Study is available in Chapter 4. I organized my Pilot Study in two phases. The phases represented the two different but consecutive stages in time that gradually involved me in doing this research.

Phase I consisted of my evaluation of the PWISEM at the end of the academic year 2002-2003. The evaluation study involved contacting the participating students and learning from them about their experiences in the Program and its overall effectiveness, as well as writing a report (for the paper version, see Kahveci, 2004). The study increased my interest to research women’s participation in science and science related fields, and specifically, my enthusiasm to investigate the interactions made available through the Program by using a thorough, theoretical lens.

Phase II represented my deeper involvement in the research context during the academic year 2003-2004 through attending the Program’s events and activities, communicating with the PWISEM students, and also making contributions to some of the
events. It also included collecting preliminary data. Given my research design, I utilized a survey instrument as a pretest in the beginning of the academic year (I discussed the instrument in the Survey Instrument section). Through participant observations (Bogdan & Biklen, 1998) I collected fieldnotes (Emerson, Fretz, & Shaw, 1995) to make written record of my observations and experiences. I also performed some preliminary interviewing, another source of data in qualitative research “used to gather descriptive data in the subjects’ own words so that the researcher can develop insight on how subjects interpret some piece of the world” (Bogdan & Biklen, 1998, p. 94). For this purpose, I selected four interviewees from the first-year PWISEM student population, and conducted an interview with each of them.

As well as narrowing down my focus and refining the frame of my research, through this preliminary work I believe that I gained much preliminary knowledge and understanding about the Program. Also, I believe that I established rapport with the PWISEM students and other staff related with the Program to a great extent. This awareness guided me through the entire data collection and analysis processes of my research.

Qualitative

The data sources in the symbolic interactionist tradition are fieldwork, autobiographies, letters (Jacob, 1987), interviews, and participant observation (Bogdan & Biklen, 1998). As well, researchers’ subjective experiences are seen as important sources of data (Jacob, 1987).

For this research project, I conducted a multi-case study (Bogdan & Biklen, 1998), which is for a single case “both a process of inquiry about the case and the product of that inquiry” (Stake, 2000, p. 436). In Stake’s terms, it was a collective case study in which understanding the cases led to “better understanding, perhaps better theorizing, about a still larger collection of cases” (Stake, 2000, p. 437). In this research I explored three PWISEM students’ experiences in the Program, and their developing science identities. I had these three cases through which my attempt was to better understand the dynamics of the Program and its impact on the participating students.
According to Bogdan and Biklen (1998), in case studies “the major data gathering technique is participant observation (supplemented with formal and informal interviews and review of documents) and the focus of the study is on a particular organization… or some aspect of the organization” (p. 55). Overall, my focus was on the impact of the PWISEM in terms of the women students’ participation in the SM&E fields. *Thick description* of the cases helped me describe in detail the cases’ “own issues, contexts, and interpretations” (Stake, 2000, p. 439). Stake suggests that in analyzing a case, data about the following need to be gathered: “1) The nature of the case, 2) The case’s historical background, 3) The physical setting, 4) Other contexts (e.g., economic, political, legal, and aesthetic), 5) Other cases, through which this case is recognized, 6) Those informants through whom the case can be known” (pp. 438-439). With this guide and the cultural-historical activity theory aspect of my theoretical framework, I targeted thick description of my three cases. As well as laying out various aspects of their lives, I explored the interactions and contradictions involved in their activity systems.

I mainly depended on participant observation, interviews, document analysis, and survey (pretest-posttest) as data collection methods. In the section that follows, I elaborate on the methods associated with the qualitative approach of my research. Then I discuss the survey instrument.

*Participant Observation*

Participant observation is one of the main methods of data collection in case studies. According to Bogdan and Biklen (1998),

People act not on the basis of predetermined responses to predefined objects, but rather as interpreters, definers, signalers, and symbol and signal readers whose behavior can only be understood by having the researcher enter into the defining process through such methods as participant observation. (p. 25)
The core of participant observation consists of observing the “activities, people, and physical aspects of the situation” (Spradley, 1980, p. 54). Bogdan and Biklen (1998) characterize this process also as fieldwork, and describe it in the following way:

Fieldwork refers to being out in the subjects’ world, in the way we have described—not as a person who pauses while passing by, but as a person who has come for a visit; not as a person who knows everything, but as a person who has come to learn; not as a person who wants to be like them, but as a person who wants to know what it is like to be them. (p. 73)

In my observations my intent was to learn about the context of the PWISEM in detail, to better understand the nature of the ongoing interactions, and to make a thick description of my research cases. Thus, I extensively participated in the events and activities of the PWISEM. During my participation, to have a written record of my experiences I took fieldnotes (Bogdan & Biklen, 1998; Emerson et al., 1995). Fieldnotes are “the written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on the data in a qualitative study” (Bogdan & Biklen, 1998, pp. 107-108). As Bogdan and Biklen suggested, I used a word-processing computer program to type my fieldnotes after I returned from each observation session. During each of the observations, I took short notes in the form of an outline so that the writing did not interfere with my observation. I expanded on this outline as soon as I returned from the field, forming as many paragraphs as possible for ease of data analysis.

The fieldnotes consisted of two parts: descriptive and reflective (Bogdan & Biklen, 1998). The descriptive part of the fieldnotes is the concern “to provide a word-picture of the setting, people, actions, and conversations as observed,” and the reflective part is “the part that captures more of the observer’s frame of mind, ideas, and concerns” (Bogdan & Biklen, 1998, p. 121). While the former refers to a more “objective” observation, the latter refers to the observer’s “subjective” feelings, ideas, and speculations. The reflective fieldnotes are marked as “O.C.,” which stands for observer’s comments (Bogdan & Biklen, 1998), and are usually written as a separate paragraph. In
my writing of the fieldnotes of my observations of the PWISEM events and activities I employed these approaches.

*Interviews*

In conjunction with participant observation, I employed interviews to collect data about cases and the PWISEM. “An interview is a purposeful conversation, usually between two people but sometimes involving more, that is directed by one in order to get information from the other” (Bogdan & Biklen, 1998, p. 93).

Types of interviews are *structured, unstructured, and semi-structured* interviews (Bogdan & Biklen, 1998). In a structured interview, the researcher uses a set of questions called “probes” designed in advance of the interview (Southerland, Smith, & Cummins, 2000). In an unstructured, or open-ended interview, the researcher encourages the interviewee to talk in the area of interest and then probes deeper (Bogdan & Biklen, 1998). Semi-structured interviews have sequence of themes and suggested questions, as well as an openness to change the questions depending on the answers of the interviewees (Kvale, 1996). Each of the types or all of them can be used depending on the research goal, and there is no “better” or “worse.”

The dominant mode of interviewing the key informants in my research was the semi-structured format since it gave me the opportunity of getting comparable data across the subjects (Bogdan & Biklen, 1998). I had interview protocols (see Appendix C for a sample and Appendix D for the Interview Consent Form) which guided me through the conversations. The questions I generated stemmed from my research questions and theoretical framework.

The information I gathered through the interviews centered on the science identities of the PWISEM students, in other words, on their views of themselves as potential full participants in the community of science. I probed for any tensions/contradictions that arose during their participation in the community of science, and examined these by mainly using the cultural-historical activity theory lens. In specific, I examined the nature of the interactions that took place among the newcomers, old-timers, and full participants (of the community of science) in the context of the PWISEM. My intent was also to follow the ideas from the survey instrument in order to
understand the constructs, which I articulated as dependent variables, more in-depth. For example, some of the focus areas in subsequent interviews (as built on previous conversations and scores on pretest items) were scientist characteristics and self positioning in the community of science, interest and confidence in pursuing a SM&E major, and any gains/losses through participation in the PWISEM. I also interviewed full participants, who were faculty members in the departments of the research participants. My purpose was to get their point of view regarding the social interactions in their respective departments. In contrast, I did not interview any of the students in the HGC group. Overall, I explored the social and cultural significance of the PWISEM in terms of the students’ participation in the SM&E fields.

I audiotaped all of the interviews, with permission from the participants, and transcribed them verbatim. A transcription is typed interview (Bogdan & Biklen, 1998), and is the data that are used for analysis. I adhered to Bogdan and Biklen’s suggestions and while typing, started a new line when a new person spoke, noting on the left who the speaker was. Similar to fieldnotes, I also organized my writing in paragraphs for ease of analysis, if a person spoke for a long time.

Documents

Documents are “materials such as photographs, videos, films, memos, letters, diaries, clinical case records, and memorabilia of all sorts that can be used as supplemental information as part of case study whose main data source is participant observation or interviewing” (Bogdan & Biklen, 1998, p. 57). According to Bogdan and Biklen, there are three types of documents: (1) personal documents, (2) official documents, (3) popular culture documents. Personal documents refer to documents that the subjects themselves have written. Official documents are produced by schools or other organizations for the purpose of record. Popular culture documents are produced for commercial purposes and some examples are TV programs, news reports, audio or visual recordings.

In this research I used the first two types as supplemental data source to the fieldnotes and transcripts. An example of a personal document that I used to get to know the PWISEM students better was their self-constructed personal homepages on the
BlackBoard site. Another one was their postings to the discussion board as a response to a probe about their definitions of science during the technology workshop. A third one was the “self-descriptions” of each of the cases. Yet another one was the content of electronic mails sent by key informants. Examples of official documents that I employed as data sources were both the PWISEM and the HGC students’ GPA records at the end of the academic year, documents distributed during the PWISEM Colloquium lectures such as syllabi and handouts, minutes from PWISEM meetings, and brochures of the Program. I used these documents as supplemental data to further my understanding of the dynamics of the PWISEM.

Quantitative – The Survey Instrument

To apply the “static-group pretest-posttest design” (Fraenkel & Wallen, 2003, p. 273) over one academic year, I started out by giving the pretest to both the treatment and comparison groups in the very beginning of the Fall 2003 semester (please see Appendix E for the pretest, and Appendix F for the letters of consent associated with it). After an extensive search of instruments, I constructed a questionnaire with insight from three different instruments (Bem, 1974; CIRP, 2000; NORC, 2004) with established validity and reliability measures, which refer to the ability of “drawing correct conclusions based on the data obtained from an assessment” (Fraenkel & Wallen, 2003, p. 158), and “the consistency of the scores obtained” (p. 165), respectively.

I organized the instrument to be composed of about ten sections (or clusters of items). Seven of the sections correspond to the seven dependent variables that I wanted to explore (explained in the Research Design). Following is a description of the other three sections:

- The technology skills questions on the PWISEM pretest served as reference for the technology workshop that was held in the beginning of the Fall 2003 semester (explained in the Pilot Study in Chapter 4). I asked the same questions in the HGC pretest for comparison purposes in terms of technology skills.
- I included a section about the factors that were influential in the students’ intentions/decisions to pursue one of the SM&E majors. These factors included
mother encouragement, father encouragement, other family member(s) encouragement, teacher(s) encouragement, media, and own interest.

- In the PWISEM pretest I asked the students why they preferred to participate in the PWISEM, including options such as being attracted to the residence hall, parental influence, recommendation of a friend previously in the Program, the opportunities in the Program, etc. My purpose was to inform the Program Director, Dr. Jones (only this section is absent from the HGC pretest).

I also gathered demographics information for the following two purposes: (1) keeping track of the students to be able to contact them later, and (2) ensuring that the same students complete the posttest.

Development

The first ten items in the first section and the items in the fifth and sixth section of the survey are originally found in the General Social Survey (GSS), the largest sociology project in the US funded by the National Science Foundation (NSF) (NORC, 2004). The purpose of the GSS is expressed as following in the NORC Web site:

The basic purposes of the GSS are to gather data on contemporary American society in order to monitor and explain trends and constants in attitudes, behaviors, and attributes; to examine the structure and functioning of society in general as well as the role played by relevant subgroups; to compare the United States to other societies in order to place American society in comparative perspective and develop cross-national models of human society; and to make high-quality data easily accessible to scholars, students, policy makers, and others, with minimal cost and waiting. (NORC, 2004, paragraph 8)

The items that I adapted from the GSS belong to the section about public attitudes toward and understanding of science and technology. The results and discussion of this study including the trend over years can be found in a recent report, *Science &*
The fourth section of the survey instrument includes the Bem Sex Role Inventory (BSRI) developed by psychologist Sandra L. Bem (Bem, 1974). It consists of 60 adjectives representing personality characteristics. The BSRI includes a Femininity scale and a Masculinity scale, each containing 20 personality characteristics. The rest 20 adjectives form a Social Desirability scale, completely neutral with respect to sex. The sex-role adjectives are based on stereotypical white conceptions of femininity and masculinity. According to Bem (1974),

the BSRI was founded on a conception of the sex-typed person as someone who has internalized society’s sex-typed standards of desirable behavior for men and women… and not on the basis of differential endorsement by males and females as most other inventories have done. (p. 157)

Also, the two scores (Femininity-Masculinity) are “logically independent” (p. 158) and do not affect each other; in other words, they are not at the two ends of a continuum. According to the inventory, a person is sex-typed to the extent that the difference between his/her Femininity and Masculinity scores is high, and androgynous, to the extent that this difference is low. Bem (1974) proposes that rather than a sex-typed individual, an androgynous person would “come to define a more human standard of psychological health” (p. 162). By utilizing this instrument in my research, my purpose was to measure the impact of the PWISEM, if any, on the participating students’ self-description of themselves in terms of sex-role stereotyping/androgyny, and if this changes over time (one academic year period which was the mandatory year for the new PWISEM students to live together in the residence hall). I, at the same time, compared the PWISEM students and the HGC students with respect to sex-role stereotyping/androgyny to see any similarities or differences.

The item in the third section of the instrument is originally found in the Florida State University’s “Survey of Incoming First-Year Freshmen and Transfers” (CIRP,
I used this item to see any differences or similarities in both student groups in terms of their determination to pursue any of the SM&E majors. I also looked for patterns of change in terms of their determination.

I constructed the last three items in the first section, which are about the nature of science (NOS) views, with insight from the open-ended Views of Nature of Science Questionnaire (VNOS) developed by Lederman, Abd-El-Khalick, Bell, and Schwartz (2002). Although these scholars and others oppose the use of traditional paper-pencil and “forced-choice” instruments to assess NOS views because these instrument types have weaknesses, are more suitable for mass assessments, and are aimed at evaluating students’/teachers’ beliefs instead of probing, understanding, and/or enhancing them (Lederman et al., 2002; Lederman, Wade, & Bell, 1998), I believe that in this particular research utilizing the short, Likert scale format of questioning gave some insight about the students’ views of NOS. I see these three items about the NOS as subsequent to the items exploring my fifth dependent variable, views on science and scientists. The conception of NOS generally refers to “the values and assumptions inherent to science, scientific knowledge, and/or the development of scientific knowledge” (Lederman, 1992), and helping students develop informed NOS views is an important and desired component of most science curricula especially in K-12 education (NRC, 1996).

In asking about the degree of influence of various factors such as parental encouragement in intending/deciding to pursue one of the SM&E majors (last section of the instrument) I was mainly inspired by the work of Seymour (1995). In her study about the loss of women from undergraduate SM&E majors Seymour (1995) found that “women differed very sharply from men in choosing SME majors through the personal influence of family, high school teachers, and other significant adults” (p. 446). Women were more likely to decide for a SM&E major under the influence of others’ suggestions, and therefore, were more likely than men to switch out of the SM&E fields since the initial decision did not reflect their personal interests and skills. My intention was to shed light on the same issue within the context of this research and to look for possible differences in terms of the influence variable between men and women student subgroups in my two samples. I did not include these items in the posttest since the pretest data provided me the necessary information on the influence variable coupled with the
information on their intended majors at that time. While assessing their retention at the end of the academic year I took into consideration the pretest scores, which gave insight on any relationship between retention and factors influencing the students’ decisions.

The “level of interest/confidence” items in the second section of the survey instrument, the technology skills items in the seventh section, and the items about the reasons for participating in the PWISEM specific to the Program students stemmed from my experience of evaluating the Program. As I mentioned before, I used the technology item scores of the PWISEM students to inform the technology workshop held in the beginning of the academic year 2003-2004. In a sense, this section served as a needs assessment, which is a context analysis process used “to assess the environment in which an innovation would be used to determine the need for the innovation…” (Dick, 2002, p. 148). I included the items relating to the participation in the PWISEM and those on the “level of interest/confidence” to mainly inform the Program Director. However, using the latter in my research as one of the lenses to explore the impact of the PWISEM on students’ participation in the SM&E majors, was essential.

Among those items on the degree of influence of various factors on pursuing SM&E majors, on reasons for participating in the Program, on the technology skills, and on the “level of interest/confidence” in the SM&E majors, in the posttest, I only included the ones on “level of interest/confidence.”

**Validity**

Fraenkel and Wallen (2003) define validity as “the appropriateness, correctness, meaningfulness, and usefulness of the specific inferences researchers make based on the data they collect” (p. 158). According to this view, it is “the inferences about the specific uses of an instrument that are validated, not the instrument itself” (p. 158). Fraenkel and Wallen emphasize the importance of the researcher giving attention to the way s/he intends to interpret the information gathered by the instrument. My intent in utilizing the survey instrument that I described above was to explore any differences or similarities between the two student groups –first-year PWISEM and HGC- in terms of their science understandings and different aspects of their participation in the SM&E majors. One
evidence to express my ability of drawing these inferences is *content-related evidence of validity* (Fraenkel & Wallen, 2003).

Content-related validity requires that the content of the instrument enables the researcher to draw meaningful inferences from the data. One way to ensure content-related validity is to ask experts in the related field to judge the appropriateness of the items (Fraenkel & Wallen, 2003). The science related items in the instrument that I utilized in this research are originally found in the last version of the General Social Survey (2001 questionnaire of Public Understanding of Science and Technology) (NORC, 2004; NSB, 2002). Fielded since 1972 (annually since then and biennially since 1994), initially 150 social scientists formed the GSS by reviewing drafts of the questionnaire, suggesting revisions and additions, and expressing their preferences by vote. A Board of Overseers composed of distinguished social scientists revise the instrument annually (NORC, 2004). Thus, I assume that the data I collected through the items I adapted from this instrument allow me to draw meaningful conclusions regarding the dependent variables I established about science. Another important aspect of content-related validity is the characteristics of the intended sample. As I indicated before, the GSS is designed for the American society. The interviewers conduct random-digit-dial (RDD) telephone surveys of adults at least 18 (Losh, 2003). In this sense, the characteristics of both the first-year PWISEM student group and the HGC student group matched the characteristics of the sample addressed by the GSS.

The sex-role items that I utilized in the instrument were the Bem sex-role inventory (BSRI) items composed of 60 personality adjectives (Bem, 1974). Bem points that in the process of the development of the items 100 Stanford undergraduates judged the adjectives. They decided to what extent the characteristics were socially desirable in the American society for both sexes. Half of the judges were men and half were women, all of which rated all the adjectives. Given that I used the inventory in the same age and culture group as its developers, and that the BSRI is the most frequently used sex-role instrument with good reliability and adequate validity (Lenney, 1991), I assume that I can draw meaningful inferences about the sex-roles of the students in my samples and relate that variable with my research questions.
I constructed the three items about the NOS views with insight from the open-ended Views of Nature of Science Questionnaire (VNOS) developed by N. G. Lederman et al. (2002). The educators validated the VNOS Questionnaire through individual follow-up interviews with respondents to ensure the appropriateness of their interpretations of the given responses. The interviewees ranged from high school students, college undergraduates and graduates, and preservice and inservice elementary and secondary science teachers across four continents. N. G. Lederman et al. (2002) argue “a high confidence level in the validity of the VNOS for assessing the NOS understandings of a wide variety of respondents” (p. 517). Although it was a limitation that I used the items in a Likert scale format, I believe these items gave some insight on any differences between the two student groups in my research.

The content-validity of the single item about being determined in the intended major need not be questionable because the item was originally present in the Florida State University’s “Survey of Incoming First-Year Freshmen and Transfers” (CIRP, 2000), addressing freshmen students. Similarly, the “level of interest/confidence” items were straightforward asking the participants to rate their current level of interest/level of confidence using a five-point scale. One evidence of validating these three items was to obtain criterion-related validity (Babbie, 1998) by comparing the scores of these items to external criteria, which would be the GPA scores of the students at the end of the academic year. The results of the posttest and the pretest pointed out high interest and confidence levels for both the PWISEM and HGC student groups, which were coupled with high end-of-year GPAs. Indeed, this harmony signals criterion-related validity.

As I emphasized before, I was mainly inspired by the work of Seymour (1995) while including the items about the degree of influence of various factors such as parental encouragement in intending/deciding to pursue one of the SM&E majors. According to Seymour’s (1995) study “women differed very sharply from men in choosing SME majors through the personal influence of family, high school teachers, and other significant adults” (p. 446) and therefore they were more likely than men to switch out of the SM&E fields. Considering the sample characteristics, and that I directly formulated the items from the above quote, my assumption was that the data I obtained from this part
of the survey would allow me to draw meaningful conclusions about the influence of these factors on students’ major choice.

Reliability

Fraenkel and Wallen (2003) define reliability as “the consistency of the scores obtained” (p. 165). Reliability is often expressed in the form of reliability coefficients, which is another application of correlation coefficients. There are several ways of estimating the reliability of an instrument. These include test-retest method, equivalent forms method, and internal consistency methods (split-half procedure, Kuder-Richardson approaches, Alpha coefficient – Cronbach’s alpha, etc.). As well, using established measures, or instruments on which there is previous evidence of reliability and validity is another way of being more confident about reliability (Babbie, 1998; Fraenkel & Wallen, 2003). Having adapted items from previously conducted surveys, like the GSS and BSRI, gave me confidence about the reliability of these items to some extent.

Other than that, I used the scores of the pretests that I conducted in the pilot study, to measure the reliability of the items with different scales in the survey instrument. For this purpose, first, I performed factor analysis among the items to check for patterns/factors and to form clusters of items representing common dimensions (Table 3-5). In the factor analysis, I excluded the BSRI, and one other item (measuring being determined in academic major) representing a dimension on its own. So, I performed the analysis for the remaining 33 items. This analysis resulted in a total of 12 factors. At this stage, I dropped three items from the instrument because their factors did not reach .50 loading (Bearden, Hardesty, & Rose, 2001). This resulted in 30 items being retained.

To estimate the reliability coefficient of the dimensions with at least two items, I performed Cronbach’s alpha tests. Those exceeding the threshold of reliable measure, which is often accepted as .70 (Fraenkel & Wallen, 2003), were as follows: femininity (.77), masculinity (.80), being informed in new discoveries (.71), and influence on major – other(s) (.76). The other dimensions did not reach the value of .70, however it is very likely that the limited number of items pertaining in each dimension and the small sample size (35 PWISEM and 63 HGC students totaling in 98) led to such a result. Fraenkel and Wallen (2003) argue that “longer tests are usually more reliable than short ones,
presumably because they provide a larger sampling of a person’s behavior” (p. 170). Similarly, Nunnally (1972) emphasizes that the more items there are on a test the higher the reliability is.

Table 3-5. Remaining survey items and their factor loadings by dimension

<table>
<thead>
<tr>
<th>Factor Item</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interest in new discoveries</strong></td>
<td></td>
</tr>
<tr>
<td>• Issues about new scientific discoveries</td>
<td>.80</td>
</tr>
<tr>
<td>• Issues about the use of new inventions and technologies</td>
<td>.87</td>
</tr>
<tr>
<td>• Issues about new medical discoveries</td>
<td>.50</td>
</tr>
<tr>
<td><strong>Interest in general scientific issues</strong></td>
<td></td>
</tr>
<tr>
<td>• Issues about environmental pollution</td>
<td>.82</td>
</tr>
<tr>
<td>• Issues about the use of nuclear energy to generate electricity</td>
<td>.83</td>
</tr>
<tr>
<td><strong>Being informed in new discoveries</strong></td>
<td></td>
</tr>
<tr>
<td>• Issues about new scientific discoveries</td>
<td>.67</td>
</tr>
<tr>
<td>• Issues about the use of new inventions and technologies</td>
<td>.79</td>
</tr>
<tr>
<td>• Issues about new medical discoveries</td>
<td>.83</td>
</tr>
<tr>
<td><strong>Being informed in general scientific issues</strong></td>
<td></td>
</tr>
<tr>
<td>• Issues about space exploration</td>
<td>.72</td>
</tr>
<tr>
<td>• Issues about environmental pollution</td>
<td>.65</td>
</tr>
<tr>
<td>• Issues about the use of nuclear energy to generate electricity</td>
<td>.80</td>
</tr>
<tr>
<td><strong>Science and scientists (I)</strong></td>
<td></td>
</tr>
<tr>
<td>• <strong>It is not</strong> important for me to know about science in my daily life.</td>
<td>.64</td>
</tr>
<tr>
<td>• A scientist usually works alone.</td>
<td>.58</td>
</tr>
<tr>
<td>• Scientists are not likely to be very religious people.</td>
<td>.62</td>
</tr>
<tr>
<td>• Scientists have few other interests but their work.</td>
<td>.70</td>
</tr>
<tr>
<td>• Something that is proven by using the scientific method is a fact, and therefore no longer subject to change.</td>
<td>.57</td>
</tr>
<tr>
<td><strong>Science and scientists (II)</strong></td>
<td></td>
</tr>
<tr>
<td>• Scientific researchers are dedicated people who work for the good of humanity.</td>
<td>.57</td>
</tr>
<tr>
<td>• Scientists are helping to solve challenging problems.</td>
<td>.80</td>
</tr>
<tr>
<td>• Most scientists want to work on things that will make life better for the average person.</td>
<td>.71</td>
</tr>
<tr>
<td><strong>Science and scientists (III)</strong></td>
<td></td>
</tr>
<tr>
<td>• Scientists are apt to be odd and peculiar people.</td>
<td>.83</td>
</tr>
</tbody>
</table>
To further evaluate the items, I performed item-total correlations (Trochim, 2000) within the dimensions. I retained only those items with corrected item-total correlations above .30 (Nunnally, 1978, as cited in Ferketich, 1991). None of the retained items fell below .33, exceeding the established standard and assuring the retention of reliable items, and none exceeded .70, which would indicate that they were redundant (Ferketich, 1991). As a result, other than the BSRI, 28 items remained in the survey instrument with reliable measures, and these were the items that I included in the posttest.

Methods of Data Analysis

Qualitative

Within the qualitative approach of my research design, I analyzed the cases without a strict concentration on comparison to avoid glossing over the uniqueness and complexities of the cases (Stake, 2000, emphasis mine). However, I still attempted to show how the phenomenon, which in this research was participating in the PWISEM,
occurred across the cases. In other words, I first analyzed each case separately and then looked across the cases. I believe the cross-comparison of the cases provided a valuable and trustworthy knowledge about the Program and its impact on the women students’ participation in the SM&E fields.

In specific, my analysis of the fieldnotes, transcripts, and documents (when appropriate) consisted of three stages: (1) open coding, (2) selecting themes, (3) focused coding (Emerson et al., 1995). For this purpose, I utilized QSR N6, a version of the NUD*IST software for qualitative data management in my work.

In open coding, the researcher reads through the fieldnotes and interview transcripts very carefully and line by line, and assigns codes to each meaningful segment, or units of data, which are pieces (paragraphs, sentences, or sequence of paragraphs) of the fieldnotes, transcripts, or documents that fall under a particular topic (Bogdan & Biklen, 1998). In this initial stage, the researcher “should seek to generate as many codes as possible… without considering possible relevance either to established concepts in one’s discipline or to a primary theoretical focus…” (Emerson et al., 1995, p. 152). During this process, the researcher writes initial memos reflecting a variety of ideas and insights, and in a sense, begins to mold a preliminary analysis of the data. By first arranging my fieldnotes and interview transcripts into many paragraphs, I went over all of the data and attached meaningful codes. After the initial coding and memoing, I selected core themes, which were the ideas among others that I decided to explore further (Emerson et al., 1995).

In coding, selecting themes, and the overall analysis of the data personal perspectives and theoretical positions often influence the researcher (Bogdan & Biklen, 1998). As I mentioned before, it is likely that my biases springing from my positionality shaped many aspects of my research, including the data analysis. Especially in selecting the themes, my theoretical framework being a blend of the theory of situated learning/legitimate peripheral participation and the cultural-historical activity theory guided me through the process of making sense out of the data. For example, some of the themes I selected include the “interactions of the individuals (newcomers, old-timers, and full participants) within the Program,” and the phenomena occurring within and between
the seven components of the cultural-historical activity theory frame, which are “subject, object, outcome, mediating artifacts, rules, communities, division of labor” (Figure 3-3).

Focused coding “involves building up and elaborating analytically interesting themes, both by connecting data that initially may not have appeared to go together and by delineating sub-themes and subtopics that distinguish differences and variations within the broader topic” (Emerson et al., 1995, p. 160). Alongside, the researcher composes *integrative memos* in which s/he explores relationships between coded fieldnotes and examines a theme more closely by linking together various observations. In the stage of focused coding, I combined the coded data under my selected themes and simultaneously wrote integrative memos reflective of my synthesis of the previously discrete data. I performed the data coding process for each individual case first, and then looked across the cases. Taken together, the coding and the themes guided me in building explanatory arguments to my research questions.

**Quantitative**

Within the quantitative approach of my research design, I analyzed the data collected by the survey instrument in the form of a pretest and posttest by utilizing the SPSS 11.0 for the computation of the statistical tests. These data played a supportive role to the themes and arguments emerging from the qualitative part. As I mentioned before, within the quantitative “static-group pretest-posttest design” (Fraenkel & Wallen, 2003, p. 273) of my research, both the PWISEM first-year student group and the HGC student group were given a pretest, the PWISEM student group received a treatment, and then both groups were given a posttest over one academic year period.

“In analyzing the data, each individual’s pretest score is subtracted from his or her posttest score, thus permitting analysis of ‘gain’ or ‘change’” (Fraenkel & Wallen, 2003, p. 273). The independent variable in my research was *academic program*, and the treatment consisted of the events, activities, and opportunities in the PWISEM. The dependent variables were: (1) interest, (2) confidence, and (3) being determined in pursuing one of the SM&E majors, (4) views on science and scientists, (5) interest in and (6) understanding of science and technology, and (7) psychological sex-role stereotyping/androgyny as measured by the Bem Sex Role Inventory (BSRI). These were
the variables of interest over which I compared the PWISEM first-year students and the HGC students. However, there were three distinct groups within these two: (1) The PWISEM first-year student group, (2) The women HGC students group, (3) The men HGC students group. While my primary interest was to compare the PWISEM women students with the non-PWISEM, or HGC women students, comparing these two groups with the men students group, as well, gave me insight into any differences or similarities across the genders with respect to the dependent variables. Although not the focus of my research, such an approach enriched my arguments and discussions, and allowed me to tie these to my literature review about “underrepresentation of women in SM&E” more tightly.

To compare the similarities or differences across the three groups in terms of my dependent variables listed above (except the “psychological sex-role stereotyping/androgyny” variable), I performed one-way ANOVA for mean differences across the groups in the pretest, and then performed it again for the posttest. Here I used inferential statistics “to make judgments of the probability that an observed difference between groups is a dependable one or one that might have happened by chance” (Trochim, 2000, p. 381).

The analysis of any differences in terms of the last dependent variable, psychological sex-role stereotyping/androgyny, was different than the others. I used Bem’s (1974) scoring guide to compute each individual’s Femininity, Masculinity, and Androgyny score. While the Masculinity score equals the mean self-rating for all endorsed masculine items, and the Femininity score equals the mean self-rating for all endorsed feminine items, “the Androgyny score is defined as Student’s t ratio for the difference between a person’s masculine and feminine self-endorsement” (Bem, 1974, p. 158). Specifically, I performed independent samples t-tests to compute these scores for each individual student. I utilized this inventory in my research to compare the three groups in terms of the percentage of significantly sex-typed or androgynous individuals within each, both in the beginning and at the end of the academic year.

The limitation in the quantitative analysis was that the two student groups (PWISEM and HGC) were not drawn with known probabilities of selection from the first-year student population in the University. Since I used the PWISEM first-year
student population as the treatment group (in a sense/resembles a *convenience* sample) and the HGC students as the comparison group, a *purposive* sample, and since these were not *probability* samples (Fraenkel & Wallen, 2003), I did not attempt to generalize my results to the whole first-year student population in the University. The conclusions I drew from the data collected with the survey instrument functioned to support or complement my interpretations and conclusions emerging from the qualitative part of my research regarding the PWISEM student group.

**Researcher**

As both a participant observer and an individual associated with the Program via means of its evaluation and my “teaching” role in the workshop, in this research I saw myself as an *active/interventionist researcher*. I embraced the assertion that “in learning about others through active participation in their lives and activities, the fieldworker cannot and should not attempt to be a fly on the wall” (Emerson et al., 1995, p. 3). It is impossible for a qualitative researcher to be completely neutral, objective, and detached from the field because “qualitative study differs from other research methods in that it features researchers themselves as observers and participants in the lives of the people being studied” (Lofland & Lofland, 1995, p. 3).

My presence in the context of the PWISEM became another factor in the PWISEM students’ experiences since I immensely interacted with them. Our interactions might have not only revealed their beliefs, but might have also altered them, thus having some impact on their lives. On the other hand, I, as an individual, have my own *positionality*, which is the “knower’s specific position in any context as defined by gender, race, class, and other socially significant dimensions” (Maher & Tetreault, 1994, p. 22, as cited in Barton, 1998, p. 28). Thus, my “personal history, biography, gender, social class, race, and ethnicity” (Denzin & Lincoln, 2000, p. 6) shaped my research proposal and my research itself, which was dominantly qualitative and “a set of interpretive activities” (p. 6). My biases springing from my positionality shaped many aspects, such as the selection of the topic, research questions, and methods of data collection and analysis. They also shaped my interpretations of the data and discussion of results.
I saw the most influential component of my positionality shaping my research as being my gender intersecting with my ethnicity. I have a strong scientific background with an undergraduate degree in chemistry education, and I am a woman in the field. On the other hand, having grown in a different culture from the American, and in a different context, might also have had influences on my interpretations of the different aspects of this research. These influences might have been in the form of tacit assumptions that I might have coming from my background.

I was born in Bulgaria, a European country with a communist regime at that time, but my ethnicity is Turkish. I have grown up in Turkey since the age of 11, and Turkey is a cultural and historical “mosaic.” It is located in the intersection of Middle East and Europe. Both regions have shaped Turkey’s history and its political and cultural structure, and it is a country of cultural and ethnic blends. As far as I have seen it, the most obvious segregation in the Turkish society is in terms of people’s class, in other words, their socioeconomic status.

Coming from a working class family has shaped my perspective of the structure of the Turkish society from our family’s point of view. My parents have always encouraged me to work hard and to “come to better a place than theirs.” They have not treated me any different than my brother because of my gender. Too, when I went to college to study chemistry, I did not experience discrimination based on my gender, and as far as I know, neither did my friends. Though, I knew that especially the engineering majors were dominated by men. So, women do not have a complete parity with men in the SM&E fields in Turkey, too, but class comes before gender in power relationships. Similarly, Rosser (1997) categorizes Turkey as a country which needs to be analyzed using a Marxist feminist lens. She indicates that in some countries including Turkey class is emphasized over gender, and for this reason, Turkey is able to produce a higher percentage of women scientists than the United States.

Overall, my experiences with segregation based on class in a different culture and context, and not that much with that based on gender, and being a woman in the scientific field shaped my positionality in a specific way. Relevantly, three dimensions emerged as influential on my research. First, the nature of my positionality guided my curiosity and enthusiasm to research gender issues in science education. Second, being a woman in the
scientific field both as a student and teacher, I believe, enabled me to better position myself in my subject and to be able to see from the perspective of the students in my research. Third, my positionality rendered some challenges for me, but I believe having an awareness of these improved my learning. While I did my best to discuss my work with my committee members and peers so that they assist me to see my tacit assumptions, I was open to learn as much as I could from this research concerning gender issues. An evidence of my learning was simply my increased awareness of these issues. For example, exploring the different strands of feminist theory helped me to position myself in the frame of existentialist feminism, which views the society as most influential in interpreting and shaping one’s gender.

Ensuring the Rigor of the Research

*Crystallization/Triangulation*

According to Creswell (1994), using methods of collecting data within both the qualitative and the quantitative approach of research is a form of *triangulation*, because the convergence of the two approaches ensures multiple methods of data collection and analysis on the same phenomenon (Creswell, 1994). Although Stake (2000) points that the traditional meaning of triangulation implies that multiple processes are used to clarify meaning, some scholars find the concept misleading. Janesick (2000) and Richardson (2000) replace triangulation with *crystallization* and offer it as a better lens to view qualitative research designs. Richardson does not agree that in postmodern texts there are “three sides” from which to approach the world and she argues that we have to move from plane geometry to light theory according to which light can be both particles and waves.

I propose that the central imaginary for “validity” for postmodernist texts is not the triangle—a rigid, fixed, two-dimensional object. Rather the central imaginary is the crystal, which combines symmetry and substance with an infinite variety of shapes, substances, transmutations, multidimensionalities, and angles of approach… What we see depends upon our angle of repose. (Richardson, 2000, p. 934)
By using the two approaches, qualitative and quantitative, and their associated methods of data collection and analysis in my research, I implemented the “crystal” metaphor which helped me clarify meanings and interpretations by looking from different angles. It also resembled the multidimensionality of the cultural-historical activity theory model which was a base of looking at various interactions and emerging contradictions among the components of the system. Therefore, the activity theoretical framework by itself ensured the “crystallization” of the research design.

**Quality Criteria**

As criteria to judge the quality/goodness of my research, I employed Guba and Lincoln’s (1989) *parallel criteria* (trustworthiness) and the *authenticity criteria* (pp. 228-251) for the “Fourth Generation Evaluation” (the details of each criterion are given in Table 3-6). Guba and Lincoln developed the *parallel criteria* parallel to the conventional criteria consisting of internal validity, external validity, reliability, and objectivity. The *hermeneutic dialectic process* is unique in the sense that it implies that researchers analyze data immediately and “feed back” responses for revision, clarification, or expansion. Similar to hermeneutic process, the authenticity criteria are rooted in constructivist assumptions (Guba & Lincoln, 1989).

The hermeneutic dialectic process is the process, or methodology of the Fourth Generation Evaluation “deduced from the basic belief system of constructivism” (Guba & Lincoln, 1989, p. 173) aiming *joint constructions*. Thus, Guba and Lincoln accept this process as its own quality control. I did not utilize this process in my research since I developed my research methodology by using a theoretical framework which I wove out of the cultural-historical activity theory and the theory of situated learning. I believe that this framework guided me effectively through this research. The quality criteria that I attempted to satisfy were the trustworthiness and the authenticity criteria.
Table 3-6. Quality criteria for the Fourth Generation Evaluation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Dependability (reliability)</td>
<td>Analyzes the stability of the data over time and involves documenting the logic of process and method decisions.</td>
</tr>
<tr>
<td></td>
<td>3. Confirmability (objectivity)</td>
<td>Assuring that the data, interpretations, and outcomes derive from the stakeholders by tracking them to their sources.</td>
</tr>
<tr>
<td></td>
<td>4. Transferability (generalizability)</td>
<td>Setting out all the working hypotheses for the study and providing extensive and careful description of the time, the place, the context, and the culture in which those hypotheses were found to be salient.</td>
</tr>
<tr>
<td>Quality Control Criteria</td>
<td>5. The Hermeneutic Process</td>
<td>The hermeneutic dialectical process of sequentially examining all constructions, including the evaluator’s.</td>
</tr>
<tr>
<td></td>
<td>6. Fairness</td>
<td>The extent to which different constructions are solicited and honored within the evaluation.</td>
</tr>
<tr>
<td>Authenticity Criteria</td>
<td>7. Ontological Authenticity</td>
<td>The extent to which participants’ own emic constructions changed to have more sophistication of use.</td>
</tr>
<tr>
<td></td>
<td>8. Educative Authenticity</td>
<td>The extent to which participants’ understanding of and appreciation for the constructions of others outside their stakeholders group are enhanced.</td>
</tr>
<tr>
<td></td>
<td>9. Catalytic Authenticity</td>
<td>The extent to which action is stimulated and facilitated by the evaluation.</td>
</tr>
<tr>
<td></td>
<td>10. Tactical Authenticity</td>
<td>The extent to which stakeholders are empowered to act.</td>
</tr>
</tbody>
</table>

Adapted from N.T. Davis, personal communication, 2001
In order to ensure the trustworthiness of the research, the credibility, dependability, confirmability, and transferability criteria must be met. To ensure a credible research, I needed to be persistently present in the research setting. In this research, I saw myself as an “active/interventionist researcher,” and was consistently involved through participant observation in the events and activities of the PWISEM. My familiarity with the Program, the students, and the staff extended to two years overall, and I believe that I built strong connection with the PWISEM students and other staff related with the Program during this period of time. This prolonged engagement helped “to overcome the effects of misinformation, distortion, or presented ‘fronts’ to establish the rapport and build the trust necessary to uncover constructions, and to facilitate immersing oneself in and understanding the context’s culture” (Guba & Lincoln, 1989, p. 237).

I also believe that sharing the (tentative) results of data analysis and research findings with committee members and peers through the peer debriefing process increased the credibility of the research.

Negative case analysis involves identifying and explaining instances/evidence that do not fit into the “working hypotheses… with an eye toward developing and refining a given hypothesis (or a set of them) until it accounts for all known cases” (Guba & Lincoln, 1989, pp. 237-238). To satisfy this criterion, I reviewed all the data with a sensitivity of explaining the phenomenon, participation in the PWISEM, in a way that no instance was ignored.

Progressive subjectivity means that I examine how my ideas change during the research. As I indicated earlier, I believe I learned from this research, and I am aware of that. Such an awareness brought in openness to learn, as well. I feel that I am more sensitive about gender issues in science and science education and will continue to be so during my future teaching as well as in the upbringing of my one-year old daughter. Progressive subjectivity also ensures that I do not give privilege of my constructions over anyone else’s and that I do not find only what I expect to find as a result of my research. The openness to learn was one way to insure that I was not trapped in my own expectations. As well, the peer debriefers played a critical role in noting such a tendency.
and challenging me about it. Nevertheless, that the findings of this research did not reveal transformation in the culture of SM&E is another evidence that as a researcher, my possible desire for such a result did not interfere with my data collection or analysis processes. In other words, I did not find what I expected to find as a result of my research.

One of the most critical techniques of establishing credibility is the member checking process. To see if they agree with my interpretations I checked with the participants during both data collection and the analysis stage. For example, during interviewing I immediately asked some follow-up questions and sought their confirmation of my understanding of what they said. After I wrote the findings, I had the participants read the relevant section and react to it. I also communicated with them via electronic mail shortly after the interviewing or member checking process to make further clarifications. In the process of member checking, some of my assertions were confirmed; others were denied, or altered.

To meet the dependability criterion, my role as a researcher was to develop a logical research design as well as to document clear and detailed explanations of my research methods. I believe that the extensive details in this chapter regarding my research design and methodology meet this criterion.

Confirmability implies that “data (constructions, assertions, facts and so on) can be tracked to their sources” (Guba & Lincoln, 1989, p. 243). My responsibility in ensuring confirmability was to keep a clear record of my data sources and the subsequent data information that I obtained from each. I organized my data sources in electronic files and folders by noting the type of the source, the date of formation, the name of the relevant participant (for the interviews), and the like. I also noted the source and the date of each quote that I used in writing my findings. Being organized and systematic was a researcher skill needed to ensure high level confirmability.

Transferability is the parallel criterion to generalizability in quantitative research. It refers to the ability of the readers to learn from and to apply the study to their own situations. The major technique of establishing transferability is thick description, which I employed in exploring my four cases. It involved providing an extensive and careful description of the time, the place, the context, and the culture of the cases (Guba &
Lincoln, 1989). I assume that readers (with various backgrounds) will be able to subjectively generalize from the cases in this research to their own personal experiences. Also, by examining the PWISEM’s influence on women’s participation in the community of science, I anticipate that my research contributes to the literature on gender equity in higher education by adding the perspective of the programs designed for women. Such a contribution may open avenues of pursuit for designing and/or improving similar programs in other universities.

**Authenticity**

The authenticity criteria are unique to the Fourth Generation Evaluation and do not speak to methods, as the parallel criteria do (Guba & Lincoln, 1989). There are five criteria to ensure the authenticity of a study: fairness, ontological, educative, catalytic, and tactical authenticity. According to Guba and Lincoln (1989), fairness refers “to the extent to which different constructions are solicited and honored within the evaluation process” (pp. 245-246). It involves giving voice to all potential stakeholders. Mutual advantage is sought. I believe that I addressed this criterion by insuring as much variety as possible in the participants I selected for interviews. Another part of the fairness criterion is obtaining informed consent from the research participants, which I did for both the surveys and the interviews (for the consent letters/forms see Appendixes D and F).

The ontological authenticity criterion involves improvement, maturation, expansion, and elaboration in individual respondents’ own emic constructions (Guba & Lincoln, 1989). As a qualitative researcher, I tried to encourage the research participants to “gain control over their experiences” (Bogdan & Biklen, 1998, p. 38). Our interactions revealed their beliefs and made them explicit not only for me as a researcher but also for themselves. I believe that they reached a higher level of awareness regarding gender issues and being women in SM&E. By encouraging them to be more clear and detailed in their answers/comments, I aimed improvement in their own thinking. Indeed, their assertions became more thorough and informative over time.

Educative authenticity is about enhancing the participants’ understanding of and appreciation for others’ constructions (Guba & Lincoln, 1989). In my interviewing the
PWISEM students, from time to time I brought in others’ (i.e., their peers’) point of view on the issues and encouraged the participants to reflect on them.

As Guba and Lincoln (1989) indicate, in catalytic authenticity the researcher stimulates action on the part of participants. Action in my research meant to catalyze, or make it easier for the PWISEM students to be involved in the externalization process of their science identities; in other words, my role as a researcher would have been to encourage the students to actively participate in reconstructing and transforming the social relations of scientific practice. However, observing the action itself, if any, was likely to be beyond the scope of this research because such transformations usually occur in much longer periods of time. To satisfy the catalytic authenticity criterion, I hoped to at least see some indication of a potential or willingness for participating in the transformation of SM&E fields. Although at the time being the women were more likely to internalize the status quo in SM&E without actively challenging it, it is my hope that the awareness they gained through participating in this research will make difference once they become more empowered, full participants in the community of science.

Similar to catalytic authenticity, in tactical authenticity the participants are empowered to act and make decisions. However, it is a full empowerment that tactical authenticity aims, and which is beyond the scope of this research. As a researcher, I was not in a full empowering position, too. Along with my intentions with respect to catalytic authenticity, I believe that I empowered the three PWISEM women in the sense that I provided them a forum for reflection and negotiation on participating in the science community, which might trigger a transformation in their science identities beyond the research experience.
CHAPTER 4

PILOT STUDY

In this chapter, I present the pilot study I conducted prior to writing my research proposal. Referred to as “stretching exercise” by Janesick (2000), this pilot study represents background work, which allowed me to develop more detailed plan about my research. In this pilot study, I practiced interviewing, observing, writing, reflecting and developing artistic skills which helped me to refine my research instrument, which is myself, and to develop rapport with the research participants (Janesick, 2000). The rest of my dissertation unfolds based on the methodology and findings that emerged in the pilot study.

The pilot study consisted of two phases, which represented the two different but consecutive stages in time that gradually involved me in doing this research. The first phase was my evaluation of the PWISEM at the end of the academic year 2002-2003. The second phase depicted my deeper involvement in the research context during the academic year 2003-2004. As regards with the second phase, I described the PWISEM technology workshop, in which I was actively involved, my observations within the context of the Program, and the preliminary interviews with four of the PWISEM students. I also presented the results of the survey which I gave as pretest to the PWISEM students and another group from the university population in the beginning of the academic year 2003-2004.

12 My involvement in the research context and the interviews with the research participants continued during the academic year 2004-2005, the findings of which I discuss in Chapter 5.
Evaluating the PWISEM

At the end of the academic year 2003-2004, I was invited by the Director, Dr. Jones, to evaluate the effectiveness of the PWISEM and to present my findings in the form of a report (for paper version see Kahveci, 2004). This invitation was possible with the recommendation of one of my major professors who knew Dr. Jones closely. Being a "formative evaluation" (Newby, Stepich, Lehman, & Russell, 2000) this study involved contacting the participating students and learning about their experiences in the Program and its overall effectiveness. The participants in the evaluation study were 40 PWISEM students (staying in the residence hall in the 2002-2003 academic year) who completed a survey and, among those, eight, who participated in interviews with me.

According to the PWISEM evaluation survey results, the middle 50% (interquartile range) of the PWISEM students varied in their responses from slightly agree to agree that their interest in a SM&E major has increased due to their participation in the PWISEM. Seventeen and a half percent (or seven students) scored on this item lower than slightly agree, which indicates their disagreement. The PWISEM students strongly disagreed (median) that their interest in a SM&E major decreased due to their participation in the Program. Also, the students agreed (median) that PWISEM activities such as internships, workshops, and field trips helped to keep their interest in a SM&E major.

The findings from the qualitative data also indicated that overall, the PWISEM provided a supportive environment that encouraged success. As most of the students emphasized, without the interactions they had through the program, they might have switched majors outside the SM&E realm much more easily. The peer backing\footnote{Peer backing is a term used by the PWISEM freshmen to describe the supportive relationships among themselves as opposed to peer mentoring, which is a term that refers to the mentoring the PWISEM freshmen received from their upperclassmen peers.}, and learning about the women scientists, mathematicians or engineers in the Colloquium lectures and career panel discussions were especially helpful to enhance their self-confidence. Also, their understanding of the SM&E disciplines deepened, and their horizons broadened about careers in the SM&E fields.
The "sense of community" was one of the best experiences the students had in the program which helped them to succeed in their majors through peer mentoring and supportive relationships. As well, the sense of community made the residence hall very different than any other hall, and in turn, the PWISEM students while living in the hall made substantial contribution to the sense of community they have had.

My evaluation of the Program and my deep involvement at that time captured my attention to women’s issues in the fields of science, mathematics, and engineering, immensely. I was attracted to this research area, and it was at this stage that I decided to head in that direction for my dissertation. Moreover, findings such as the apparent effectiveness of the Program and the students’ emphasis on some conceptions such as “sense of community” highlighted some avenues to pursue in my research. This stage of my pilot study increased my interest and enthusiasm to investigate the interactions made available through the Program by using thorough, theoretical lenses.

Studying the PWISEM

At the beginning of the academic year 2003-2004 I considered it very important for the quality of my future research on the PWISEM to maintain my bond with this community (this was also closely related with the quality criteria I utilized in my research). Continuing to be involved in the context of the Program meant attending its events and activities, communicating with the PWISEM students, and even making contributions. All of these were going to involve collecting preliminary data; therefore I obtained the Human Subjects Committee approval in the beginning of the semester.

The PWISEM Technology Workshop – Fall 2003

I was actively involved in one of the PWISEM Colloquium lectures in the Fall 2003 semester, the PWISEM technology workshop. One of the PWISEM Faculty Advisory Committee members had proposed it to the Program Director, and I was one of the collaborators. The workshop was the fourth lecture in the course syllabus and announced by the Program Director in the first meeting.

As a form of needs assessment, the technology skills items on the pretest (see Appendix E) informed us about the computer and technology experiences that the students already had. Since they were experienced (used computer regularly for word
processing and/or Internet exploration) overall (Figure 4-1), we could proceed to introduce other areas that might be useful for them to know during their education such as performing effective searches on the Internet to find information, using the electronic resources of the University, and getting familiar with the functions of the BlackBoard, which I explain below.

Figure 4-1. Median values for technology skills items.

We held the workshop in the technology equipped classrooms of the University containing personal computers, one for every student. The 35 PWISEM students were divided in two sections. The PWISEM Faculty Advisory Committee member was
responsible for one section, and I was responsible for the other section. We collaborated in producing a two-page handout to be distributed during the workshop. The lecture lasted 50 minutes.

Among the topics covered was the use of the BlackBoard, an online course support system “founded to transform the Internet into a powerful environment for the education experience” and used by thousands of institutions in 145 countries (BlackBoard, 2004). Prior to the lecture, I had reorganized the BlackBoard and designed it in a way that it met the PWISEM students’ needs; its use became optimized for the Colloquium. It became a specific site where the PWISEM students could find links to library resources, the course syllabus and other handouts distributed during the lectures. They also learned how and where to enter their personal information so that they could get to know one another better through the site. Another topic was forwarding their university electronic mail accounts to another account of their preference. The last task they performed was to participate in an online discussion via the BlackBoard site. As a discussion prompt, I had posted an open-ended question prior to the lecture, which was from the VNOS Questionnaire (Form C) of Lederman et al.(2002). The prompt contained the following:

Please keep in mind that there is no "right" or "wrong" answer to the question below and your own comments are the answer.

What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)? (BlackBoard, September 15, 2003)

We expected the students to write their own response as well as to reply to one of their classmates. In total, 85 messages were posted, including the original comments and the responses to one another. My analysis of the data regarding the NOS question revealed that besides categorizing science as the study of life more than half of the comments pointed to science as based on facts and to other disciplines of inquiry such as religion as based on beliefs. In their responses to the question the students often used
words like *hard facts, evidence, proof, (search for) truth, discovery, beliefs, and faith.*

According to the students’ comments evidence and proof were central in scientific work, and beliefs, values and faith were central in the other inquiries.

Science is fact. Or trying to achieve what is true in the universe. Religion and philosophy are based on beliefs but lack hard evidence.

Science is a study of things around us. It is a study of things that are real, that can be touched, heard, seen. Other disciplines, such as religion and philosophy, are more the study of the abstract, of things that cannot be touched, heard, or seen. Science is very real and very solid, and other disciplines are less concrete and have more room for interpretation.

(BlackBoard, September 15, 2003)

According to the results of the data analysis concerning the NOS question above most of the PWISEM students had “more naïve views” of the empirical aspect of NOS (Lederman et al., 2002, p. 514) in the beginning of the academic year. These views were important in terms of giving insight on how they viewed science and scientists, and themselves within that scientific culture.

Overall, the technology workshop was productive for me as a researcher in terms of getting to know the context and the students better. It furthered my involvement as an “active/interventionist researcher.” It became yet another source of data.

*PWISEM Observations*

Through the Fall 2003 semester I continued my relation with the PWISEM. I was involved in *participant observations* (Bogdan & Biklen, 1998), one of the data sources in the symbolic interactionist tradition of qualitative research. I attended most of the events and activities organized in the Program. During my participation in the events and activities, in order to make “written record of these observations and experiences” (Emerson et al., 1995, p. 1), I took *fieldnotes*, another data source in qualitative studies, central to participant observation (Bogdan & Biklen, 1998).
Other than actively participating in the technology workshop, in the Colloquium lectures I sat in the classroom as if I was one of the PWISEM students and listened to the lecturer. I observed the students’ interactions both with the speaker and with one another. I joined most of the groups in their field trips to the research facilities at the University. In PWISEM socials such as the Ropes course, which I explained next, I interacted with the students on an informal basis and they often encouraged me to join them in the activities they were doing. In one of the informal meetings that a staff associated with the Program organized in the lounge of the residence hall, I participated in discussions with the staff member and a couple of upperclassmen PWISEM students about how to improve the Program. Overall, I felt I became yet another factor in the context of the PWISEM.

One of the activities I attended was offered in the beginning of the academic year 2003-2004, a day before the fall semester started. It was the Ropes course (a day-long activity), which took place at the University’s reservation, a 73-acre facility, with 10 active acres, located on a beautiful lake with unique natural setting where canoeing, kayaking, picnicking, swimming and many other activities can be done. The purpose of the Ropes course was to build “group cooperation, decision-making skills, self-confidence, positive risk taking, group cohesion, trust, self-esteem, leadership skills” (University Web site, 2004).

According to Dr. Jones, the purpose of having the first-year PWISEM students (and some non-first-year PWISEM students) attend this course was to establish a sense of community among the new PWISEM students by fostering their interactions with some of their upperclassmen peers in the Program. The purpose was simply “to get them know each other and become friends” (Fieldnotes, August 24, 2003). They had not done that last year, and Dr. Jones hoped that the Ropes course would advance the interactions better among the participants.

As far as I observed, the Ropes course functioned exactly to fulfill the goal that Dr. Jones set. All of the activities included team work and solving problems as a team. They were about building trust relationships and friendships. After each activity the young women talked to each other and planned strategies to solve the problems at hand. They helped one another to achieve the tasks. As they reflected on their experiences by
forming circle at the end of almost each activity, they learned one another’s name and about the things each of them liked to do. One of the activities, for example, was called “Trust Fall.” One of the team members was to fall on her back from a certain height onto the “zipped” hands of the others. It was the most challenging and the risky one, one which could not be done without trusting the people who were to hold the falling person; it was all about trust. The activity added much to the alliance of the young women, and also to their relations with Dr. Jones, who also participated in the activity and performed “the fall” (Fieldnotes, August 24, 2003).

The Ropes course contributed to the peer mentoring in the Program, as well. Since some of the non-first-year PWISEM students also joined the course, there was opportunity to exchange ideas about the classes and different aspects of college life with the first-year PWISEM students. For example Lisa, a sophomore at that time, and a dedicated young woman, talked sincerely with her first-year friends on our way to the reservation, and her best advice for them was to “know their professor very well and be good with him/her” (Fieldnotes, August 24, 2003). She pointed to the importance of good professor-student relationships for academic success.

The Ropes course was a good opportunity for me as a researcher to establish rapport with the PWISEM participants and Dr. Jones. I had a chance to chat with the young women and Dr. Jones on an informal basis which contributed much to our relations.

I also attended most of the Colloquium lectures in the Fall 2003, and the associated field trips to the research facilities of the University, which I mentioned before. There were 13 lectures in total, four of which were assigned to the field trips. I attended seven of the lectures and three of the field trips.

In the first Colloquium lecture Dr. Jones emphasized that the goal of the lectures was “to introduce them [the first-year PWISEM students] to the University, to foster communication, and to do that through the math, science and engineering fields since normally it was more difficult to deal with these.” The goal also included “stimulating the students’ interest in these areas” and “taking ideas from these courses” (Fieldnotes, August 25, 2003) In this first lecture Dr. Jones gave me the opportunity to talk about my research, request the PWISEM students’ consent to participate in it, and have them
complete the pretest (Appendix E). While talking about the staff involved in the PWISEM, she introduced me as the evaluator and the researcher of the Program, and said that I was both helping with the evaluation and conducting my dissertation research. Having Dr. Jones’ support made it easier for me to establish connection with the students.

Being a component of the PWISEM, the Colloquium lectures represented a context, in which the goal of the Program was enacted via different means. For example, besides giving detailed internship information, Dr. Jones organized an internship panel where several upperclassmen PWISEM students talked about their experiences with the internships they got through the Program. One of these students emphasized that the internships through PWISEM were excellent (Fieldnotes, October 13, 2003). On the other hand, the lectures were also informative regarding the facilities of the University such as the libraries and online resources (i.e., electronic career portfolio), and supportive in terms of basic life issues such as adjusting to college, time management, social life, and studying techniques. The field trips to the Meteorology Department, Antarctic Core Facility, Chemical Engineering Department and to other major research facilities were opportunities for the students to see the different programs and to get first-hand information about the various SM&E majors. Finally, at one of the lectures the students discussed and decided on speakers in the next (Spring) semester. The young women offered names, voted and decided on the speakers they wanted to hear. They took the responsibility of contacting and inviting them, as well. Having guest speakers in the spring semesters and involving the PWISEM students in the events and activities more actively were ideas which emerged from the results of the Program evaluation for which I had been responsible.

The lectures had a relaxed atmosphere. Besides being informative they were opportunities to enhance the coherence of the PWISEM community. At the end of a busy day the students found a chance to hear and talk about their fields, future careers, and college life. By the end of the semester I could see how the sense of community improved; the PWISEM students often laughed, made jokes to each other and seemed more like a community than individuals on their own who happened to be in the same class.
The Pretest: Student Demographics and Group Relationships

In this section I present the PWISEM students’ and the HGC students’ demographics and their comparison as revealed by my analysis of the survey that I gave as pretest (see Appendix E) in the first week of the academic year 2003-2004. The response rate for the PWISEM students was 100%; in other words, all of the students completed the survey. The HGC students had a response rate of 64% (63 out of 99 students completed the survey).

As I discussed in Chapter 3, my dependent variables of interest were: (1) interest, (2) confidence, and (3) determination in pursuing one of the SM&E majors (CIRP, 2000), (4) views on science and scientists (NORC, 2004), (5) interest in and (6) understanding of science and technology (NORC, 2004), and (7) psychological sex-role stereotyping/androgyny as measured by the Bem Sex Role Inventory (BSRI) (Bem, 1974).

Besides the discussion of the results regarding the dependent variables I also presented the results of the items concerning the factors that were influential in the students’ intentions/decisions to pursue one of the SM&E majors, and the results of the questions specific to the PWISEM students about why they chose to participate in the Program. I also described any relationship that existed among the groups. 14

1. **Interest:** In terms of their interest in pursuing one of the SM&E majors, the three groups embodied no significant difference (Table 4-1). In other words, all of the students expressed almost the same level of interest, and the group means ranged from 4.40 to 4.65 (5.00 being the highest interest score on the scale and the 1.00 being the lowest, see item 14 on the pretest in Appendix E). The mean score of 4.40 belongs to the PWISEM student group and the mean score of 4.65 belongs to the HGC men students group.

14 The groups were: PWISEM students, HGC female students, HGC male students.
Table 4-1. *Comparison of the student groups in terms of interest and confidence*

<table>
<thead>
<tr>
<th>Items</th>
<th>PWISEM Students (N=35)</th>
<th>HGC Women Students (N=29)</th>
<th>HGC Men Students (N=34)</th>
<th>One-way ANOVA p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Item 14 (Interest)</td>
<td>4.40</td>
<td>0.70</td>
<td>4.45</td>
<td>1.06</td>
</tr>
<tr>
<td>Item 15 (Confidence)</td>
<td>3.94</td>
<td>0.80</td>
<td>4.03</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Pretest, 2003

* Confidence interval: 95%

2. **Confidence**: When compared in terms of their confidence in pursuing one of the SM&E majors, the students did not differ significantly (Table 4-1). Like the interest variable, the confidence variable revealed that all of the students expressed similar level of confidence in being in these majors. The mean scores for the groups ranged from 3.94 to 4.24 (again, 5.00 being the highest confidence score on the scale, and 1.00 being the lowest, see item 15 on the pretest in Appendix E). There was numerical difference among the mean scores of three groups such that the PWISEM students scored the lowest (3.94) and the HGC men students scored the highest (4.24) on the confidence scale. In fact, as seen in the table, the HGC men students had a noticeable deviated score from both the women student groups.

3. **Determination in pursuing one of the SM&E majors**: According to student responses to Item 16 (see the pretest in Appendix E) and the results of crosstabulation and Chi-square test, 69.0% of the HGC women students were “certain of their academic major” as compared with 54.3% PWISEM students and 44.1% HGC men students (Table 4-2). The highest percentage of students who “have narrowed down their academic major to several possibilities” were from the HGC men student group (47.1%). However, there was no statistical significance
in terms of the relationship between academic program and determination in major.

Table 4-2. Academic program and determination in major crosstabulation

<table>
<thead>
<tr>
<th>Determination (Item 16)</th>
<th>PWISEM Students</th>
<th>HGC Women Students</th>
<th>HGC Men Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
</tr>
<tr>
<td>You are certain of your academic major.</td>
<td>54.3%</td>
<td>69.0%</td>
<td>44.1%</td>
</tr>
<tr>
<td>You have narrowed down your academic major to several possibilities.</td>
<td>37.1</td>
<td>27.6</td>
<td>47.1</td>
</tr>
<tr>
<td>You need assistance in deciding.</td>
<td>8.6</td>
<td>0</td>
<td>5.9</td>
</tr>
<tr>
<td>You do not know at the moment, but you will decide on your own.</td>
<td>0</td>
<td>3.4</td>
<td>2.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0% (35)</td>
<td>100.0% (29)</td>
<td>100.0% (34)</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Pretest, 2003

4. Views on science and scientists: Regarding items 1 through 13 (see pretest in Appendix E) that included the NOS items, in general, the student groups expressed similar comments. The only statistically significant differences existed in terms of items 7 and 9 (Table 4-3) 15.

According to the analysis of variance and the Tukey HSD post-hoc analysis that I performed, the PWISEM students differed significantly from the HGC men students in their responses to item 7, “scientists are apt to be odd and peculiar people,” $F(2, 95)=5.53$, $p=0.005$. The PWISEM students were more likely to disagree with the statement while the HGC men students were more

15 The scale for these items was as following: 1-Strongly agree, 2-Agree, 3-Disagree, 4-Strongly disagree.
likely to agree. This difference implied a different point of view to the image of scientist with respect to gender.

Table 4-3. *Comparison of the student groups in terms of views on science and scientists*

<table>
<thead>
<tr>
<th>Items</th>
<th>PWISEM Students (N=35)</th>
<th>HGC Women Students (N=29)</th>
<th>HGC Men Students (N=34)</th>
<th>One-way ANOVA p value&lt;sup&gt;*&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Item 1</td>
<td>3.60</td>
<td>0.55</td>
<td>3.41</td>
<td>0.63</td>
</tr>
<tr>
<td>Item 2</td>
<td>3.20</td>
<td>0.58</td>
<td>3.21</td>
<td>0.49</td>
</tr>
<tr>
<td>Item 3</td>
<td>2.64</td>
<td>0.82</td>
<td>2.79</td>
<td>0.62</td>
</tr>
<tr>
<td>Item 4</td>
<td>1.91</td>
<td>0.74</td>
<td>1.83</td>
<td>0.54</td>
</tr>
<tr>
<td>Item 5</td>
<td>3.41</td>
<td>0.50</td>
<td>3.31</td>
<td>0.60</td>
</tr>
<tr>
<td>Item 6</td>
<td>1.77</td>
<td>0.84</td>
<td>1.48</td>
<td>0.69</td>
</tr>
<tr>
<td>Item 7</td>
<td><strong>2.91</strong></td>
<td>0.66</td>
<td>2.62</td>
<td>0.56</td>
</tr>
<tr>
<td>Item 8</td>
<td>2.00</td>
<td>0.59</td>
<td>1.93</td>
<td>0.37</td>
</tr>
<tr>
<td>Item 9</td>
<td><strong>3.09</strong></td>
<td>0.74</td>
<td>2.69</td>
<td>0.66</td>
</tr>
<tr>
<td>Item 10</td>
<td>3.12</td>
<td>0.59</td>
<td>3.07</td>
<td>0.46</td>
</tr>
<tr>
<td>Item 11</td>
<td>1.69</td>
<td>0.58</td>
<td>1.79</td>
<td>0.50</td>
</tr>
<tr>
<td>Item 12</td>
<td>3.17</td>
<td>0.66</td>
<td>3.34</td>
<td>0.55</td>
</tr>
<tr>
<td>Item 13</td>
<td>2.11</td>
<td>0.90</td>
<td>2.00</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Pretest, 2003

* Confidence interval: 95%

† Significant mean differences at the 0.05 level

In this case, the women students in the PWISEM drew their image of scientist as more integrated with the ordinary society (scientists as normal people) while the HGC men students tended to see this image as more extraordinary.

The post-hoc analysis also revealed that the PWISEM student group differed significantly from the HGC men students group in terms of their responses to item 9, “scientists are not likely to be very religious people,” $F(2,$
95)=4.05, \( p=0.021 \). The PWISEM students were more likely to disagree to the item than the HGC men students group.

5. *Interest in* and (6.) *Understanding of science and technology*: In general, all students expressed similar comments to the items 18 through 29 related with interest in and understanding of science and technology (see pretest in Appendix E). The only exception was item 19, which was about interest in “issues about the use of new inventions and technologies.” The HGC men students were significantly more likely to be “very interested” in these issues than the HGC women group, \( F(2, 95)=4.55, \ p=0.013 \) (Table 4-4)

7. *Psychological sex-role stereotyping/androgyny as measured by the Bem Sex Role Inventory (BSRI)*: According to the results of the students’ responses to the BSRI, I constructed a crosstabulation table (Table 4-5), which shows the percentage of the students in each group who categorized as near feminine, feminine, near masculine, masculine, or androgynous.

According to the crosstabulation and Chi-square test the relationship between academic program and BSRI categories was statistically significant, \( \chi^2(8, N=98)=21.527, \ p=0.006 \). There were more students who were categorized as feminine in the HGC women students group than in the other two groups. At the same time, among the two women student groups the percentage of students who were categorized as masculine was much higher in the HGC women student group (13.8% vs. 2.9%). There were no students in the HGC masculine group who were categorized as near feminine. Among the two women groups the percentage of the near feminine students was much higher in the PWISEM students group than in the HGC women students group (28.6% vs. 6.9%). There were more students who were categorized as near masculine in the PWISEM students group (17.1%) than in the HGC women students group

16 The scale for items 18-23 was as following: 1-Very interested, 2-Moderately interested, 3-Not at all interested, and for items 24-29 it was as following: 1-Very well informed, 2-Moderately well informed, 3-Poorly informed.
In terms of androgyny, the most androgynous students were the HGC men students (55.9%). Overall, the pattern of the student distribution among the BSRI categories showed that noticeably, the bulk of the HGC men students was in the androgynous category and the rest HGC men were mainly categorized as near masculine or masculine while the two women groups were distributed more evenly among the five categories.

Table 4-4. Comparison of the student groups in terms of their interest in and understanding of science and technology

<table>
<thead>
<tr>
<th>Items</th>
<th>PWISEM Students (N=35)</th>
<th>HGC Women Students (N=29)</th>
<th>HGC Men Students (N=34)</th>
<th>One-way ANOVA value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Item 18</td>
<td>1.49</td>
<td>0.51</td>
<td>1.69</td>
<td>0.61</td>
</tr>
<tr>
<td>Item 19</td>
<td>1.57</td>
<td>0.56</td>
<td>1.66</td>
<td>0.48</td>
</tr>
<tr>
<td>Item 20</td>
<td>1.26</td>
<td>0.44</td>
<td>1.28</td>
<td>0.46</td>
</tr>
<tr>
<td>Item 21</td>
<td>1.86</td>
<td>0.73</td>
<td>1.83</td>
<td>0.54</td>
</tr>
<tr>
<td>Item 22</td>
<td>1.91</td>
<td>0.74</td>
<td>1.79</td>
<td>0.68</td>
</tr>
<tr>
<td>Item 23</td>
<td>2.11</td>
<td>0.72</td>
<td>2.10</td>
<td>0.56</td>
</tr>
<tr>
<td>Item 24</td>
<td>2.11</td>
<td>0.63</td>
<td>2.14</td>
<td>0.52</td>
</tr>
<tr>
<td>Item 25</td>
<td>2.06</td>
<td>0.54</td>
<td>2.17</td>
<td>0.54</td>
</tr>
<tr>
<td>Item 26</td>
<td>1.94</td>
<td>0.59</td>
<td>1.97</td>
<td>0.57</td>
</tr>
<tr>
<td>Item 27</td>
<td>2.34</td>
<td>0.73</td>
<td>2.52</td>
<td>0.57</td>
</tr>
<tr>
<td>Item 28</td>
<td>2.40</td>
<td>0.65</td>
<td>2.21</td>
<td>0.62</td>
</tr>
<tr>
<td>Item 29</td>
<td>2.74</td>
<td>0.44</td>
<td>2.55</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Pretest, 2003

* Confidence interval: 95%

† Significant mean differences at the 0.05 level

Other than the seven dependent variables, there were two areas in which I collected data, as well. One of these areas consisted of the factors that were influential in
the students’ intentions/decisions to pursue one of the SM&E majors (items 39 through 44, see pretest in Appendix E).

In their responses to item 39 about “mother encouragement” the PWISEM students differed significantly from the other groups as mother encouragement being more influential, $\chi^2(4, N=97)=10.168$, p=0.038 (Table 4-6). The PWISEM students also scored the lowest on item 40, “father encouragement” (1.97 vs. 2.41 and 2.15) among the three groups, but the difference was not statistically significant. The result for item 39 implied that a general characteristic of the PWISEM student group was that they had a relatively stronger maternal support in pursuing a SM&E major, which supported Seymour’s (1995) findings that women were more likely to choose their major under the influence of others, especially family. However, opposing the same researcher’s findings, mother influence was not a factor for the women in the PWISEM to switch out of SM&E at the end of the academic year (as revealed by the posttest results discussed in Chapter 6). This opposition explains the positive impact of the PWISEM on the women’s retention to a great extent.

Table 4-5. Academic program and BSRI categories crosstabulation

<table>
<thead>
<tr>
<th>BSRI Categories*</th>
<th>PWISEM Students</th>
<th>HGC Women Students</th>
<th>HGC Men Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feminine (t ≥ 2.025)</td>
<td>14.3% (35)</td>
<td>17.2% (29)</td>
<td>2.9% (34)</td>
</tr>
<tr>
<td>Near Feminine (1 &lt; t &lt; 2.025)</td>
<td>28.6</td>
<td>6.9</td>
<td>0</td>
</tr>
<tr>
<td>Androgynous (-1 &lt; t &lt; +1)</td>
<td>37.1</td>
<td>48.3</td>
<td>55.9</td>
</tr>
<tr>
<td>Near Masculine (-2.025 &lt; t &lt; -1)</td>
<td>17.1</td>
<td>13.8</td>
<td>23.5</td>
</tr>
<tr>
<td>Masculine (t ≤ -2.025)</td>
<td>2.9</td>
<td>13.8</td>
<td>17.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0%</td>
<td>100.0% (35)</td>
<td>100.0% (34)</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Pretest, 2003
* The category cutoff points for the t value are taken from Bem’s (1974) study involving undergraduate students from two different universities.

17 The scale for these items was as following: 1-Very influential, 2-Somewhat influential, 3-Not influential.
The second area in which I collected data concerned the reasons the PWISEM students participated in the Program. According to the students’ responses to items P1 through P8 (see pretest in Appendix E), the most important factor of their participation was the opportunities provided through the Program (Item P8) (Table 4-7).

Table 4-6. Comparison of the student groups in terms of the factors influential in their intentions/decisions to pursue one of the SM&E majors

<table>
<thead>
<tr>
<th>Items</th>
<th>PWISEM Students (N=35)</th>
<th>HGC Women Students (N=29)</th>
<th>HGC Men Students (N=34)</th>
<th>One-way ANOVA p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Item 39</td>
<td>1.89</td>
<td>0.72</td>
<td>2.38</td>
<td>0.68</td>
</tr>
<tr>
<td>Item 40</td>
<td>1.97</td>
<td>0.79</td>
<td>2.41</td>
<td>0.68</td>
</tr>
<tr>
<td>Item 41</td>
<td>2.20</td>
<td>0.83</td>
<td>2.59</td>
<td>0.63</td>
</tr>
<tr>
<td>Item 42</td>
<td>2.03</td>
<td>0.75</td>
<td>2.24</td>
<td>0.69</td>
</tr>
<tr>
<td>Item 43</td>
<td>2.63</td>
<td>0.60</td>
<td>2.62</td>
<td>0.49</td>
</tr>
<tr>
<td>Item 44</td>
<td>1.03</td>
<td>0.17</td>
<td>1.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Pretest, 2003
* Confidence interval: 95%
† Significant mean differences at the 0.05 level

Table 4-7. Mean/standard deviation scores of the items concerning reasons for participating in the PWISEM

<table>
<thead>
<tr>
<th>Items</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item P1</td>
<td>1.89</td>
<td>0.72</td>
</tr>
<tr>
<td>Item P2</td>
<td>1.97</td>
<td>0.79</td>
</tr>
<tr>
<td>Item P3</td>
<td>2.20</td>
<td>0.83</td>
</tr>
<tr>
<td>Item P4</td>
<td>2.03</td>
<td>0.75</td>
</tr>
<tr>
<td>Item P5</td>
<td>2.63</td>
<td>0.60</td>
</tr>
<tr>
<td>Item P6</td>
<td>2.03</td>
<td>0.75</td>
</tr>
<tr>
<td>Item P7</td>
<td>2.63</td>
<td>0.60</td>
</tr>
<tr>
<td>Item P8</td>
<td>1.03</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Source: PWISEM Pretest, 2003, N=35
The second important factor was being in a safe environment away from home (item P1), and the third important factor was the residence hall where the PWISEM students lived (item P2).

The pretest results revealed that although mostly similar, there were significant differences in certain areas among the three groups of students such as views of scientists, interest in science and technology, and factors influential in the students’ intentions/decisions to pursue one of the SM&E majors. As well as being informative regarding subject demographics in the beginning of my research, the results were important in terms of change/sameness observations over a period of time in posttest comparisons, which take place in later chapters.

*Interviews with the PWISEM Students*

I conducted four interviews (Bogdan & Biklen, 1998), one with each student, in the middle of the Fall 2003 semester. The length of the interviews ranged from 25 minutes to 41 minutes, with an average of 32 minutes. I audiotaped the interviews and transcribed them verbatim. I used the QSR N6 software for data management.

I derived the interview protocol (see Appendix C) for the first set of interviews with these four students mainly from my research questions. Also, my “activity systems on the periphery” theoretical framework and its components guided me in formulating the questions. I used the cultural-historical activity theory as a lens to determine the system components (Figure 3-3 in Chapter 3) through my conversations with the students. As I mentioned before, my intention and eventual goal in this research was to look for possible *internalization* or *externalization* processes resolving the *contradictions*, and leading to an *expansive cycle* or transformation of the system, in the context of the PWISEM.

As I described in the previous chapter, in order to have a range of perspectives from which to understand the phenomena, the PWISEM, I selected the four cases of my research so that they are from different (intended) majors within the SM&E realm and from different ethnic backgrounds. Carol was Hispanic, intending to major in environmental engineering. Debbie was African-American and wanted to be a nursing major with the goal of entering medical school afterwards. Lena was White and her goal
was being a civil engineer. Reyna was Caucasian and aimed to major in biology. In the following section I analyzed each case by looking through separate lenses of the cultural-historical activity theory and then make cross-comparisons.

**Carol**

Carol was the one who spoke least. She talked when it was necessary (i.e., to respond to my questions) and avoided any off-topic conversation. Part of it might be due to her busy schedule as she was to go to class right after our meeting. Carol’s *object* (see Carol’s activity triangle in Figure 4-2) was to become an environmental engineer, work for the government for a while, and eventually open her own engineering firm. She sounded very determined and ready to take on any challenge she encountered on her way.

One of the challenges Carol mentioned was that science had been a men-dominated field for a long time and as an effect of that she was one of the few women in her class. She made the point “that makes it more of a challenge” (Carol, Interview 1, November 14, 2003) to stay in the major and be successful. Given her description of science as men-dominated field and her own situation as one of the few women in class, the *rules* of the activity she was in were making it hard to accomplish the object. This situation represented a contradiction between the rules and the object (Figure 4-2), and there was one more aspect adding to that. During our conversation Carol strongly emphasized that she was told many times environmental engineering was a hard major and lots of students failed. Carol commented:

> … All they do is tell us at the school like, “Oh look to your left, look to your right, someone is not going to be here next year, like 30% of the people fail…” Like they are always telling us all the bad stuff and it’s pretty… it gets pretty scary… They make you have second thoughts about it. (Carol, Interview 1, November 14, 2003)

Although Carol seemed to be influenced to some extent by what people said her determination in pursuing the major made her “unhear” these negative opinions. In other
words, Carol was experiencing a contradiction but that contradiction was being resolved within herself without forming a restraining effect on the activity system.

\[\text{Figure 4-2. Carol’s activity system in engineering.}\]

… But then the pluses 95% of the people that do pass [graduate] leave with the job they want, making the money they want, and doing what they want. So, it’s kind of a sacrifice that is worth it at the end… So maybe they are just doing that to scare us? But, it works. It makes you think about it twice, but like I don’t know, I have just decided that I am not going to be one of those 30% other people [who drop out of the major]. I am going to be one of the 95…. (Carol, Interview 1, November 14, 2003)
The negative comments people made about being in her major were more of a driving force than a discouraging factor for Carol. However, she was cognizant of the time and effort it would take her to go through the major. The “sacrifice” she was ready to make was one which would take from her social life, and this situation represented another contradiction between the subject and rules (Figure 4-2).

Carol was a member of several communities: the PWISEM community, the environmental engineering community, and the general community of science and math. Part of the requirements for her major consisted of taking various science and mathematics courses. As I mentioned before, she was one of the few women in her major. At some points, her major community interfered with and contradicted her object, being an environmental engineer. For example, Carol mentioned that once one of her men peers at the engineering school came up to her and said she was too “girly” to be an engineer. Carol seemed not to “take this to heart.” Likewise, other men who were her peers considered her role as one of the few women in class to be a minor one in the group projects, which led to a contradiction between the division of labor and Carol’s objective (Figure 4-2). Carol mentioned: “Well, now that I think about it, because like we had to do a presentation and they were like, “Oh, well, we will do all the work and you can just go up and present it.” (Carol, Interview 1, November 14, 2003) Carol faced this contradiction, too, and took action towards resolving it. She stated: “I stood up to them. I was like, “No, I still want to help you guys do it, I understand what is going on” (Carol, Interview 1, November 14, 2003). Considering Carol’s intentions about her future in the major and her attitudes toward the challenges she was facing it is apparent that her tendency was toward resolving any contradiction. Since resolving contradictions makes an activity system stronger and more open to transformation via the internalization and externalization processes, Carol seemed to have potential to reach her outcome.

As seen in Figure 4-2 Carol’s outcome was “adding more personality to the field” (Carol, Interview 1, November 14, 2003). In Carol’s opinion women and men added different aspects to science, and if men dominated then the field lacked values. Thus, participating in science as a woman was essential. Moreover, it was important that
women did science the way they were without trying “to fit” or acquire stereotyped masculine characteristics.

I am going to be a girly scientist. Like I’m still going to be a like a very, I’m very, very feminine. I am still going to maintain that… Yea, like I am still going to be a professional in everything, but I am not going to change my way of dressing or anything just to fit more into the field… Cause like I am a new generation… Different personality as opposed to just like masculine. But then again a lot of women change their ways just to fit in more. So I know I am going to add more personality to the field. (Carol, Interview 1, November 14, 2003)

Finally, Carol enjoyed being in the PWISEM and getting to know other women in science or engineering majors. Especially the young PWISEM women intending to pursue an engineering major shared a network which included studying, going to classes together, or simply, spending time together. Carol added much to the Program’s dynamics by encouraging her peers to pursue engineering majors. Carol talked, for example, about how one of her friends in the PWISEM kept asking her about her major and about being woman in the major. Carol strongly recommended that her friend pursue an engineering major and assured her that there was no need to change in order “to fit.” Finally, her friend decided to go into engineering.

The internship opportunities provided by the Program were of a special importance to Carol. In general, the PWISEM as a mediating artifact and a community was an important factor for Carol to accomplish her object. One thing that had a potential to create contradiction with her aim to be an environmental engineer, though, was the inconvenient timeframe of the Colloquium lectures. Being at a late hour on a weekday, the lectures added to the burden of her already busy schedule and since she was tired at the end of the loaded day she could not concentrate to engage fully.
Debbie

Debbie was talkative and interestingly she mostly expressed herself by acting out her conversations with people. She often tended to go off-topic, though, since she was trying to remember every detail of her conversations. Debbie was determined regarding her goals but she felt anxious because of the challenges waiting her in the coursework and exams.

Debbie’s object was to become a nurse and then enter medical school to be an obstetrician/gynecologist (see Figure 4-3 for Debbie’s activity triangle). She wanted to be a nurse or a medical doctor in order to help people. She enjoyed health professions.

Debbie believed that women did science more intricately than men. Besides this, she commented that women should participate more in science in order to “better their education about the fields” and not depend on men in certain areas related with science (Debbie, Interview 1, November 14, 2003). Debbie believed women needed to participate as much as men in the science fields and know as much as men did.

Debbie was pleased with her science and mathematics courses at the University. She especially liked her mathematics instructor and emphasized that she was “very caring teacher” (Debbie, Interview 1, November 14, 2003). So, the courses as mediating artifacts (Figure 4-3) were fulfilling their role as mediators to Debbie’s object. However, Debbie mentioned a factor that was distracting her in her studies. The University rules for class registration were a little problematic in her major since seniors had priority to register for certain classes and when it came to freshmen and sophomores the classes were already full. This represented a contradiction between the rules and Debbie’s object in the activity system (Figure 4-3). Its resolution could be possible only when the University administration was involved.

Another contradiction that apparently existed in Debbie’s activity system (between the subject and object, Figure 4-3) was her self-confidence about pursuing science. She was a little concerned about the load and “hard”ness of her courses in nursing. Debbie once said: “I will just try to get through it” (Debbie, Interview 1, November 14, 2003). She was a little relieved, though, when she talked with her major advisor (from the nursing community) who mentioned that community service was as
important as her academic base in being successful. For this reason, Debbie had been working voluntarily at a local hospital at the time.

Debbie said the PWISEM was a valuable experience for her. Although at first she was attracted to it because the dorm provided was nice and she had stayed in it the previous year, so she knew it, after her participation in the Program she liked being together with women in her major. Debbie also liked the variety of the Colloquium lectures.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{activity_system}
\caption{Debbie’s activity system in nursing.}
\end{figure}

\textit{Mediating Artifacts:} Science and mathematics courses at the University, community service, PWISEM events

\textit{Subject:} Debbie

\textit{Object:} Becoming nurse, getting into medical school

\textit{Outcome:} ?

\textit{Rules:} University rules for class registration, PWISEM rules and organization, culture of community of science

\textit{Communities:} PWISEM community, nursing community, general community of science and math

\textit{Division of Labor:} Roles within and between communities
According to my conversation with Debbie at the time, the contradictions in her activity system seemed not to have their resolutions yet, and it appeared that Debbie’s goal was to complete her nursing major requirements successfully and then enter the medical school. Her tendency was more towards *internalizing* than *externalizing* and *transforming*, meaning that she would accomplish her object without an *outcome* (Figure 4-3).

*Lena*

Lena was the only one among the four women who addressed me by my last name and the prefix “Mrs.” She seemed formal and was sensitive to my questions; she talked carefully so that everything was answered. She was direct with me and also talked about herself very confidently. Lena’s *object* was to be a civil engineer (see Figure 4-4 for Lena’s activity triangle) and work for an independent firm on a private scale. She mentioned how she wanted to design buildings, roads, bridges and make a living that way.

Lena was very determined in pursuing her major. The fact that she was a woman did not discourage her in any way. She was cognizant that in general there were fewer women in science, mathematics and engineering, and that women were often discouraged from being in these fields. She believed that this was mostly because of the society attributing women certain roles\(^\text{18}\), and because of the way girls were raised\(^\text{19}\). She emphasized that this was changing, though.

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18 Existentialist feminist perspective, suggesting that women’s “otherness” is caused by society’s interpretation of biological differences, and not by the biological differences themselves (Rosser, 1997).

19 Psychoanalytic feminist perspective, explaining gender differences resulting in male dominance with the fact that in society women are the primary caretakers for most infants and children (Rosser, 1997; Weedon, 1997).
you should, you know, clean the house, you should have children,” and stuff like that. Nowadays, more of the moms are encouraging the daughters to go out and do [science], so hopefully they won’t hold like society, and people and girls themselves won’t hold themselves down from going out and doing it [science]. (Lena, Interview 1, November 12, 2003)

![Activity System Diagram](Figure 4-4)

**Subject:** Lena

**Object:** Being civil engineer, working for independent firm

**Outcome:** “Change” in science

**Mediating Artifacts:** Encouragement and support of the family, science and mathematics courses at the University, residence hall environment, PWISEM field trips

**Rules:** Professors’ load, campus structure, PWISEM events schedule

**Communities:** PWISEM program community, civil engineering community, general community of science and math

**Division of Labor:** Role of the professors in the academic major

*Figure 4-4. Lena’s activity system in engineering.*

Lena talked about the way her family raised her as a big factor in her intention to pursue engineering major. Lena pointed that her family was “a big athletic family” and
that her father was a football coach. He always supported her to learn science; he encouraged her to play with legos, blocks, etc., toys that are typically coupled with boys. Lena said she never played with dolls. She watched and played football, and her mother loved to watch football, too. Lena also mentioned a characteristic of her personality by saying: “So, just people telling me that I can’t do it makes me want to go out there and do it even more” (Lena, Interview 1, November 12, 2003). So given the family and personality factors, which were also related, it was no surprise that Lena was eager to pursue engineering.

Besides the encouragement and support of the family, the science and mathematics courses at the University were efficient *mediating artifacts* on Lena’s way towards her object. Lena enjoyed her science and mathematics courses and noted that they were not as hard as she had been told before she came to college (Lena, Interview 1, November 12, 2003). She also said that she had always been good at mathematics and science and she had always enjoyed them.

While mentioning her professors, Lena indicated that they almost disappeared right after class and it was hard to see them because of both theirs and her loaded schedule. “They [the professors] are very busy up here [in college], because they have so many more students, and they have to try to please everybody...” (Lena, Interview 1, November 12, 2003). This represented a *contradiction* between the University *rules* about the professors’ loads (at least in civil engineering) and Lena’s object since she could not get help when she needed it. Since the professors were not able to quite fulfill their roles as advisors outside class, as well, it was also a contradiction between the *division of labor* and Lena’s object (Figure 4-4). Although the resolution of these contradictions necessitated the involvement of the University administration, they seemed not to have a crucial effect on Lena’s activity system. That was because she was very determined in pursuing civil engineering and she enjoyed her courses. She was also very self-confident that she could succeed in her major. She was “a pretty competitive person,” and she always tried to do her best without measuring herself against other students. Lena summarized her intentions by stating that there were not really many barriers that would stop her [from being a civil engineer] (Lena, Interview 1, November 12, 2003).
Another inconvenience Lena was experiencing was the location of the engineering school. Its being off-campus represented a slight contradiction between the rules and Lena’s object, but she resolved it by having her own car. In short, Lena’s determination and readiness to face any difficulty/contradiction while pursuing her major were indicators that she was likely to accomplish her object and reach her outcome (Figure 4-4).

As seen in the figure Lena’s outcome was to make a “change” in science. By “change” Lena meant the following: first, the number of women doing science would increase (the ratio of women and men scientists would change), and second, the more women participated the more science changed. She expressed her comments with the following sentences:

Hopefully more women get into it… because a lot of people just think of men as scientists, and they don’t even think that women could make good scientist, but… hopefully that’ll change.

Well, they [women] can, like, they look at things differently. Depending on what they’re doing, a woman can be very influential in the science, like… the way people look at things… they can look from the woman’s point of view, feeling like, “Well, this product would work better for a woman if this was here,” you know, stuff like that. It just gives a different perspective with the different backgrounds, and the different teachings… Maybe the different backgrounds might make the science a little different.

(Lena, Interview 1, November 12, 2003)

Lena talked about the residence hall environment provided by PWISEM and how she liked it. She enjoyed being with other PWISEM women in the same major and having the same goals. That assisted her in keeping herself motivated in the field. Another PWISEM factor that helped her to stay motivated was the field trips to the research facilities of the University. She liked the field trips more than the in-class Colloquium lectures because the field trips represented a “hands-on” activity, where she could be
actively engaged and have direct experience in her learning (McCarthy, 2005), and which she believed were more interesting, informative and science related. Given Lena’s comments about PWISEM, the Program as mediating artifact was fulfilling its role to a great extent for her to accomplish her object. Not being a major one, there was a contradiction stemming from the Program between the rules and Lena’s object, though. Lena pointed to the inconvenient timeframe of the Colloquium lectures, as Carol did. Lena’s loaded schedule during the day did not allow her to concentrate and participate fully in the lectures given in the late evening. She also wished the lectures were more science related instead of having subjects like giving information about the facilities of the University (i.e., libraries, electronic career portfolio) and covering issues such as adjusting to college, time management, social life, and studying techniques.

Reyna

Reyna looked the most feminine among the four women both with regards to her dressing style and her apparent personality characteristics. She talked only to answer my questions and when she talked her shyness was evident. Frequently her mimics and body language, like trying to avoid eye contact, portrayed a charming young woman. Her voice was soft and especially when talking about how she grew up she expressed a childish excitement.

Reyna’s object was to be a biologist (see Figure 4-5 for Reyna’s activity triangle). She was interested in animal biology and also in marine biology. Reyna mentioned how her family, and especially her father supported her and her sister to pursue science, and how their parents actually tried to raise them as boys since they did not have any sons. Nevertheless, Reyna was glad to have her family’s support and encouragement as mediating artifact to her object.

My dad, he is not biologist, but that’s what he majored in college, he got a biology degree. And… he always, like, pushed us to… I don’t know… go out and explore nature, and he bought us the… it’s like National Geographic for kids, you know, I forgot what it’s called, but it’s, like, the kid version… he wasn’t like, he wasn’t, like, mean or anything he wasn’t
like “you have to do this” but he just kind of suggested to take a look, yeah… And we liked it. (Reyna, Interview 1, November 13, 2003)

Reyna especially mentioned one of her professors at the University as very caring and supportive. He was teaching mathematics and he made himself almost always available to his students. Reyna indicated that she was surprised in a good way about that since she had not expected college professors to be like him (Reyna, Interview 1, November 13, 2003). Her experience with this professor was an important factor and mediating artifact for her to feel encouraged to pursue her major.

PWISEM was another mediating artifact for Reyna towards her object. She enjoyed being with women in the same major or taking the same science classes with them. Reyna pointed how PWISEM would help her accomplish her object as follows: “It helps to be more focused and generate better ideas, different ideas, I guess…” (Reyna, Interview 1, November 13, 2003). Reyna mentioned a PWISEM rule that she did not like, though. She wished the Colloquium lectures were not mandatory so that she did not go to the ones that were not interesting to her. Since she thought she was losing time while attending every single lecture this represents a bit of contradiction between the rules and Reyna’s object (Figure 4-5).

Other contradictions existed between the subject and the object. Reyna emphasized that she was “definitely not very strong in chemistry” and that she did not like it. Given that she had to take several chemistry courses as a requirement in her major, this was a contradiction that she would have to face. However, Reyna was very determined to be a biologist, so she had already made a decision. Reyna stated: “I think organic chemistry will be the hardest but… and I may not make the best grades, but I’ll pass. I have to make sure I pass because I really want to do this…” (Reyna, Interview 1, November 13, 2003). A second contradiction existed between the subject and the object which was about Reyna’s social life interfering with her work. Reyna mentioned she was going out so often with her friends that there was little time left to study. Reyna needed to think and make decisions about her time management in order to be able to resolve this contradiction.
Reyna’s *outcome* was making a difference in her field and also making the world a better place (Figure 4-5). She leaned toward making her career in research and not in academia although she knew she would not be paid well. Reyna’s hope was to make the world a better place by helping to protect the environment or saving endangered species. Since Reyna was very determined in her field she was likely to resolve the contradictions in her activity system and accomplish her outcome via *externalization*, which would be looking from a different perspective and coming up with new, unusual, but valuable ideas to solve environmental problems.

**Cross-comparisons**

Although some similarity existed, the four women were diverse in terms of their activity systems. The contrast among them points to each of the women’s *positionality*
(personal history, biography, gender, class, ethnicity, etc. in a specific context and history) (Barton, 1998), and positionality is essential when making sense of an individual’s activity. Some of the positionality axes like personal history and family factors were interwoven in the activity systems’ components that I constructed for the young women.

Carol and Lena were both intending to pursue engineering majors, and both were very confident that they could handle being in their majors and succeed. Both had outcomes to reach and they were directly related with the (masculine) nature of the field of science. The two women’s outcomes included changing aspects of the field of science. Carol’s outcome consisted of “adding more personality to the field” (Carol, Interview 1, November 14, 2003) and she was very determined not to “try to fit” and give up her feminine characteristics. Similarly, Lena’s outcome was to “change” science (Lena, Interview 1, November 12, 2003), but it had a different aspect from Carol’s. Carol’s goal of change was more in line with the radical feminist perspective, which included questioning the patriarchal structure and challenging it (Rosser, 1997; Scantlebury, 2002; Weedon, 1997). Lena’s goal of change was more related with changing the ratio of women and men scientists so that there are more women in the field. Her goal of change was more in line with the liberal feminist perspective, according to which sameness with men and equality is essential (Scantlebury, 2002; Weedon, 2000).

Debbie’s and Reyna’s self-confidence to pursue science was not as apparent as it was in the other two women. Both Debbie and Reyna mentioned how “hard” the courses in their majors would be, and how they would “try” to get through them. Thus, both emphasized an object rather than an outcome. Although Reyna had an outcome (to effectively solve environmental problems and make the world a better place), it was related with scientific research, and not with the nature of the field, as it was in Carol’s and Lena’s case.

Family support and encouragement was an important mediating artifact for both Reyna and Lena. Both emphasized that father encouragement was essential for them to do science and that their fathers raised them “accordingly,” which meant encouraging them to play with “boy toys.” Lena seemed to reflect the way she was raised as she

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20 A broader discussion of the feminist theories is available in Chapter 2.
enacted more of the stereotyped masculine characteristics both in her talk and body language. Not surprisingly Lena was categorized as *near masculine* according to the BSRI on the pretest. On the contrary, Reyna was categorized as *near feminine*. In contrast, Carol and Debbie endorsed both masculine and feminine characteristics and rated as *androgynous* (Bem, 1974).

The significance of the PWISEM for all of the women interviewed was in terms of sharing a network of peers in the same majors. They all emphasized that it was crucial for them to meet and live together with other women from the same science, mathematics, and engineering majors. That made it easier to stay in the major and keep themselves motivated. The women in the PWISEM studied and went to courses together, and also shared other aspects of social life. Each of them had the psychological comfort that others were going through the same challenges and that they were not alone. From the cultural-historical activity theory perspective, PWISEM represented a strong *mediating artifact* that had a constructive interaction with the women’s object.

**Conclusions**

My preliminary data collection in the Pilot Study including the data in the evaluation report, the fieldnotes, the discussion board postings, the pretest data and the interviews represented the wide end of a funnel, a metaphor used by Bogdan and Biklen (1998) to describe the start of case studies. According to this metaphor in the beginning the researchers collect data in order to decide what to do and where to go with the study. In time, they make the specific decisions about the setting, subjects, and data sources of the study. They continuously modify the design and the procedures; “from broad exploratory beginnings they move to more directed data collection and analysis” (p. 54).

Reflecting Bogdan and Biklen’s assertions I believe I gained much preliminary knowledge and understanding about the Program as well as narrowing down my focus and refining the frame of my research, through this preliminary work. I also believe that I established rapport with the PWISEM students and other staff related with the Program to a great extent. My involvement in the Program since the Spring 2003 semester resulted in productive data collection and analysis experiences, which allowed for the *thick description* (Stake, 2000) of the PWISEM as well as my four cases, both qualitatively and
quantitatively. For example, the results of the pretest helped me to understand the demographics of all the students involved and make comparisons between the PWISEM and the HGC groups. By using the cultural-historical activity theory as a lens, I was able to explore the activity systems the four young women were involved, in detail.

As a final comment, I believe the Pilot Study helped me to move from the broad to the narrow end of the funnel. I believe I elaborated on my research site and subjects to a great extent. I decided to primarily collect more in-depth data from the four PWISEM students and other key informants so that I could construct more detailed activity triangles. Also, I needed to refine my interview protocol(s) as well as agenda of interviews. My focus of research was on a possible shift/change in the PWISEM students’ science identities, and also on internalization/externalization/transformation processes in the light of the cultural-historical activity theory. My analysis of the posttest was very important in terms of supporting my exploration for possible change. Such awareness gained through preliminary work guided me through my future data collection and analysis process in my dissertation research.
CHAPTER 5

FINDINGS: INDIVIDUAL CASES

Introduction

This chapter includes the individual case analyses for each of the interview participants of my research. These analyses are a follow-up to the preliminary interviews, which I conducted for the Pilot Study of my research. In the Pilot Study (Chapter 4) I had explored the four women’s activity systems during the first months of their entry to college and the PWISEM (fall semester of the academic year 2003-2004).

At that time, although some similarities existed, the women were diverse in terms of their activity systems, a reflection of their positionality (Barton, 1998), which was also influential in their identifications of themselves as scientists. The significance of the PWISEM for these women at this point in their college careers was in terms of sharing a network of peers in the same majors. The follow-up interviews, which I analyze in this chapter, took place during the participants’ sophomore year (the academic year 2004-2005). As I mentioned before, the focus of my research was on a possible shift/change in the PWISEM students’ science identities, and also on internalization, externalization, and transformation processes in the light of the cultural-historical activity theory (Engeström et al., 1999). Thus, following up with interviews after one academic year was essential in terms of addressing any change or contradictions, and illuminating the influence of the PWISEM on these women’s participation in the SM&E fields more in depth.

Although I had started out with four participants, after the summer break of the year 2004 I withdrew one of the women, Debbie, from the research after several unsuccessful attempts to contact her. After that incidence, I based my research on three participants, Carol, Lena, and Reyna, who were my “opportunity to learn,” a primary
criterion in selecting cases (Stake, 2000, p. 446). As I mentioned in Chapter 3 in the discussion of the selection process of the interview participants, Carol intended to major in environmental engineering, Lena intended to major in civil engineering, and Reyna was majoring in biology (Table 3-2).

I also supported my case analyses with data from interviews with three faculty members. Dr. Ross was in College of Engineering, and Prof. Schwartz and Dr. Gordon were in the Department of Biological Sciences. All three were women, involved in science and related fields, but it is important to note that none were actively involved in scientific research. Dr. Ross was the Director of Industry and Research Services for the College of Engineering. She viewed her role as an active industry and government partner. “It’s a multipurpose role in which I am consistently interfacing with industry partners, government partners and our faculty” (Dr. Ross, Interview, October 25, 2004). Prof. Schwartz had an undergraduate degree in biology and was pursuing her Ph.D. in educational evaluation as she worked in the Office of Education organizing a program to involve promising high school students in scientific research at the university. Dr. Gordon, also in the Office of Education, had Ph.D. and previous research experience in neuroscience, and was the director of the aforementioned office that specialized in educational outreach programs enhancing science teaching activities in K-12 education.

With the recommendation of one of my major professors who knew these women closely and was involved in educational research with them, I selected them as key informants regarding the social interactions in their respective departments, or their communities. The positions they held were vital but yet peripheral in the community of science, so these women’s real life experiences and perspectives from a peripheral but all-encompassing angle informed my research in terms of the cultures of their disciplines. These perspectives, in turn, allowed me to understand better the communities each of the research participants was involved as well as the stated or unstated rules of these communities.

The findings include extensive passages of narrative data. I first presented the data descriptively followed by interpretation based on my theoretical framework for each of the participants. The thick descriptions and rich details that follow illuminated the undergraduate women’s journey from being newcomers to becoming old-timers with
respect to the new newcomers, from a situated learning theory perspective (Lave & Wenger, 1991). In my research, the early phase of this journey was their entrance to college with their simultaneous participation in an interstitial community of practice (Lave & Wenger, 1991), the PWISEM. I closely analyzed these women’s interactions within the Program from a symbolic interactionist perspective (Jacob, 1987). The three women’s cases also spoke to the internalization and externalization processes during this journey from a cultural-historical activity theory perspective (Engeström et al., 1999). I interpreted their experiences within the components of the cultural-historical activity theory and elaborated on any contradictions that existed. My entire theoretical base, which I named “activity systems on the periphery” (Chapter 3), revolved around the women’s participation in the SM&E fields, their identification of themselves as women scientists within science, and the dynamics of the PWISEM influencing this identification.

Carol

I am a sophomore in college majoring in environmental engineering. I am very confident and independent. I am not afraid to speak my mind. I am a very outgoing person who is not afraid to approach people. I also believe that I am very easy to get along with, and I find that I befriend people very easily. I am not afraid to walk up to someone and introduce myself. I am a very goal-oriented person. When I set my mind to doing something I will do everything in my power to achieve it. While at times I do face bumps on the road I always do everything in my power I can to overcome them. I am a very strong believer that everything happens for a reason. I believe that it is very important to have a social life because you must have social skills to face the real world. I am a very feminine woman and while that is often not accepted in my field I am not willing to change that for anyone. The way that I am, is the way that I am, and I feel that does not make me any less of a person than someone not as feminine or different than me. I do not believe that anyone can tell you that you are not good enough or that you cannot do something. I believe that if you want to do something
and you set your mind to it you can accomplish anything you want in life. I feel that my confidence, independence, and open mind will help me become a successful engineer who will add personality and femininity to a male-dominated field. (Carol, electronic mail, March 05, 2005)

This was Carol’s description of herself, written by her in response to a request during a member check process (Guba & Lincoln, 1989). It was a rich portrayal delineating Carol’s personality and ideas about science and being a woman scientist, in her own words.

**Meeting Carol**

It was at an awards ceremony of the PWISEM in the fall semester of 2004 when I renewed contact with Carol after our last conversation since the previous fall. The ceremony was one of the traditional PWISEM events, which Dr. Jones intended to organize each year to present awards to the Program’s most successful participants and to celebrate their academic achievements. Carol was one of the 13, 2003-2004 PWISEM women who received recognition for an award (PWISEM Awards Ceremony Brochure, 2004), which was an indication of her success in her major.

At this meeting, Carol appeared more mature as she talked much more comfortably and forcefully compared to last year. She seemed to have adjusted to college life better and to be more self assured. She was wearing a sleeveless top along with a miniskirt and sandals, making her look noticeably feminine. As I approached her for a chat and request for interviews, her enthusiasm about participating in the research was apparent. Her body language and attentive way of listening and talking made me feel “very welcome” in her world. We had a quick conversation, part of which was personal. Carol made it convenient for me to meet her by clearly pointing to the days which were good for her and saying “just to e-mail her” for exact times (Fieldnotes, October 20, 2004).

**Prospective Feminine Engineer, Politician, and/or Mother?**

Becoming a sophomore enhanced Carol’s already positive sense of confidence in pursuing environmental engineering. During her freshman year, she learned more about
her major and how to balance her expectations, which she expressed in the following words:

Oh, [my confidence] is probably higher. I am more confident now because last year it was just all brand new to me and now it’s like I understand and I have learned [that] you are not always going to get the grade you want in a class and you are not always going to get the best professor. (Carol, Interview 2, October 28, 2004)

Ironically, Carol witnessed many of her peers in the major dropping out, which made her believe what she had heard last year was true.

The people that I had in my first year experience class… so many… they are just dropping like flies… until I found it I didn’t expect it at all, I just had thought they were scaring us, you know… to scare us, but it’s true. (Carol, Interview 2, October 28, 2004)

Despite the fact that environmental engineering appeared to be difficult and taxing, Carol was very determined in her major. Her determination stemmed from her strong and goal-oriented personality, as she herself said. Carol described herself as being strong and different in the following way: “I feel that I am different from other women in my field in that I am very feminine and outgoing, and I do not mind standing out from the rest” (Carol, Interview 3, March 05, 2005) As of her goal-orientedness, Carol mentioned that she had a bulletin board attached on the wall at home where she put her goals for her grades in all of her classes –all A’s- as well as her other goals in life. “I kind of just forget about it but every once in a while when I look at it, I don’t know, it just helps me studying more. It just keeps me there… keep going through and focusing” (Carol, Interview 2, October 28, 2004). She also knew that those students who remain in the major –about 30% of the students- “leave [college] with the job they want, making the money they want and doing what they want” (Carol, Interview 2, October 28, 2004). That was another motive that helped Carol to stay focused in her major.
Carol’s goal of working for the government in the Environmental Protection Agency (EPA) was still there since the last year. She also kept thinking about the option of opening her own engineering firm. Besides these, another goal of Carol’s, which “just came to her,” was getting involved into politics. This “new outlook/calling” (Carol, Interview 2, October 28, 2004) as she named it, was her new interest, and she seemed somewhat committed to it. However, despite this new interest, her interest in her major did not waiver. Carol explained: “Yeah, I want to go into politics, I want to go to law school, I just want to do it all sometimes, but I know I can’t” (Carol, Interview 2, October 28, 2004). Although she considered switching her major to political science, she stayed in engineering because she believed she could get involved in politics after she became an engineer, and not vice versa.

Relevant with her high interest and confidence in the major, Carol enjoyed her courses at the university. However, there was one course that she did not enjoy, and it was the physics class.

I guess it’s also related to the teachers teaching it, there is a possibility it being a very interesting class but it’s not taken to that point, it’s just… [He] keeps… makes it as difficult as he could possibly make it… He just does [the physics course as] normal lectures but he is just… I don’t know. The recitation days, like, the TA just isn’t good at all, he doesn’t help, he doesn’t do what he is supposed to do. (Carol, Interview 2, October 28, 2004)

In other words, Carol had a negative reaction against traditional didactic teaching, as most women in Seymour’s (1995) study had. Cronin and Roger (1999) also include didactic teaching approaches as one of the reasons women experience difficulties in SM&E. Seymour (1995) argues for aspects of learning environments in which women (and many young men) would feel most comfortable “-particularly those which are interactive, cooperative, experiential, and learner-focused-” (p. 470). Such elements, in fact, belong to proposed science education reform calling for pedagogical shift from a
teacher-centered, textbook-based instructional paradigm to a student-centered, inquiry-based model (Von Secker, 2002).

Carol mentioned that she approached her physics professor about the way the teaching assistant taught the recitations. The professor promised her “to go after all the TAs” (Carol, Interview 2, October 28, 2004) however, she believed that he did not make any effort for improvement.

[My physics professor] was like, “Oh, I am going to go around and sit in all of the classrooms, see how to improve him” and he never did that. Unless he went… like, my TA has two classes, when I wasn’t there but I don’t think he did anything to improve him at all. (Carol, Interview 2, October 28, 2004)

Despite this unsuccessful attempt -because her confrontation with the professor did little to help the situation,- she felt that she had to find a way to do better in physics and she actively pursued outside help. “The physics department has tutoring guy and I just go to that, he is so much better than the teacher and the TA combined, so it works” (Carol, Interview 2, October 28, 2004). The tutor was funded by the physics department.

Unlike her physics class, Carol was very happy with her calculus class, and she implied this was largely due to the teacher.

I am taking Calc 2 and I had heard, like, it was insanely difficult, and I guess I was just expecting the worst. It’s not an easy class, but it’s not as horrible as I expected and my teacher is actually really good. So, I am doing a lot better than I expected. (Carol, Interview 2, October 28, 2004)

Despite what seemed to be Carol’s confidence, in general, Carol found it difficult to approach her teachers. “It’s just really hard to get a relationship with your professors here [at the university]; I don’t think I have ever had a relationship with any of my professors here” (Carol, Interview 2, October 28, 2004). Her statement demonstrated that she actually had an expectation of personal pedagogical relationships with her professors
in college (Seymour, 1995). Carol thought the reason was probably due to the faculty’s overcommitted schedules. Dr. Ross’ comments support this assertion as she described that in the field of engineering usually the faculty members’ teaching and research loads and the number of students they had, made personal relationships with undergraduates too difficult to manage.

Carol described the SM&E fields as men-dominated, which spoke to her interpretation of the culture of the community of science at this institution. This was supported by Dr. Ross’ description who explained the numbers of women and men both at the undergraduate and faculty level:

About 25% of our students are women students and in most colleges of engineering around the country you will see that only 11 to 15% of the engineering school population are women. So, we feel like we are really doing a good job in graduating minority students, particularly African-American students and women.

[However], only about six out of 90… of our faculty are women. (Dr. Ross, Interview, October 25, 2004)

Despite her characterization of SM&E as men-dominated, Carol also pointed to the increasing number of women in engineering and suggested that the field was changing.

It’s just like… forever and always you know, it’s probably how we were raised, it’s probably like, [we were told] men are the smarter ones or the more talented ones and like… when you go back and learn history there is [sic] very few women, and you learn about [women] that [sic] contributed to the world… So, it’s just kind of like, I don’t know, for some reason just like the [engineering] field has stayed more male-dominated, but I think it’s for sure probably changing. Like, I think in a few years there will be a lot more girls, and I think eventually it will be equal. I think there is [sic] a
Carol was cognizant that, she, as a woman was an exception in her major, and because of her markedly feminine style\(^{21}\), she was an atypical engineering student. She was atypical in two fronts: she was different not only from the men in the major, but also from her women peers who enacted less feminine ways of being women. She did not mind being unusual, though. Carol had personality characteristics like being ambitious, goal-oriented, and independent, which allowed her to make hard decisions such as remaining in the major no matter what without giving up her feminine style.

Yeah, I’m very feminine. I’m very big girly girl. So, I guess this is different. You know, when I go to engineering school I feel a little odd at place but I don’t know, I like it… It’s almost all boys; it’s a very male-dominated field and I feel that girls who are in it are not very, very feminine, you know, at least to the level that I am, so I guess I could feel odd sometimes, you know, probably like the only person in the classroom with [a] skirt, you know, or just like sandals or something but I don’t mind it at all. I should be still who I am, I don’t think I need to change that. (Carol, Interview 2, October 28, 2004)

Carol was determined to maintain her feminine style not only at college but also after graduation. When it came time to find a job, her intention was not to accept the job at the first place if the employer was to decide based on her appearance or force her to change her style.

Like, if I was ever to be offered a job and told I have to change the way I dress or something I’d turn it down… Because what does the way I dress

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\(^{21}\) By “feminine style” I refer to Carol’s womanliness in terms of dressing and appearance since she talked about it as mainly composed of these aspects and not in terms of disposition.
have anything to do with what I am going to bring to the company. Like, I
don’t think that one thing affects the other, you know, I don’t think that
someone who is not as feminine as I is better to do the job than I am.
(Carol, Interview 2, October 28, 2004)

Carol was also ready to make her voice “heard” whenever she needed to do so. “I know
when to be quiet and stuff but I am just not afraid to speak my mind” (Carol, Interview 2,
October 28, 2004). Carol explained further:

I am not afraid to speak my mind with anyone, although with professors I
do hesitate because they are above me, but if I ever feel that I do not agree
with something, I do not mind approaching them. I will be nice and polite
but also get my point across. (Carol, Interview 3, March 05, 2005)

She would “speak her mind” with the aforementioned employer, too. “I would turn down
that job [but] I would not do it without a fight” (Carol, Interview 3, March 05, 2005).

When talking about jobs, Carol appeared aware of the long hours a research
scientist or a faculty member had to work. For this reason, she was hesitant to go into
these kinds of jobs. In contrast, she thought the EPA was a perfect place for her, also
because of its flexible work hours which would allow her to have time for family. Her
mother was a good role model for her in terms of the working schedule.

I actually know some workers in EPA, and it’s actually 9 to 5 job but they
get a day off every 10 days, like every 10 working days they get a day off,
they also get all those holidays, so it’s kind of like a 9 to 5 job, kind of
coincides with school, you know, you get the same days off, it’s the
government, you know, you get all those pluses, so… It’s good because I
want to see my family, and my mom is a teacher, so she has always been
there, we didn’t have school, she was there, you know, she works 8 to 3
and, you know, she doesn’t work in the summer and all of that, so, she has
always been there and that… it really helped more, so that’s kind of like
what I would want, also, to also be there for my kids… (Carol, Interview 2, October 28, 2004)

So, it seemed that the type of the job Carol wanted in the EPA was more of a managerial/supervisory type rather than working in the field or laboratory. As shown in the above quote, it seemed that this decision was influenced by other considerations, those of personal life and family instead of the nature of the actual work. Carol wanted to be a high-ranked engineer, a professional engineer (PE), who does not do as much field work as other engineers but “sign papers and approve designs.” “Eventually I would want to become a professional engineer and then they just pretty much sign off for other engineers that aren’t PEs yet, to go and do the stuff” (Carol, Interview 2, October 28, 2004). In the engineering profession it is important to note that professional engineering is not considered as “masculine” as craft engineering, and these two are set in conflict with each other (Faulkner, 2000). According to Faulkner (2000), this is an example of “conflicting masculinities around the abstract/concrete dualism” (p. 786) since professional engineering is based on abstract theories, and craft engineering involves more hands-on experience, challenging the “manhood” of professional engineers.

Carol had an active social life. She believed that enhancing her social skills would play a major role in becoming a successful engineer. According to Carol social skills were as important as academic achievement to be successful in the SM&E fields because real life experiences were essential for success. She commented: “Especially in something like math, science and engineering [there are] skills that you need to work with people. Not one person makes a pill; it takes a group of people to make a pill” (Carol, Interview 2, October 28, 2004). Carol seemed to recognize and value the collective nature of scientific work “–in sharp contrast to a popular stereotype of science as a lonely, isolated search for the truth… Scientific research cannot be done without drawing on the work of others or collaborating with others” (NAS, 1995, p. 3).

Although Carol had often found herself in a dilemma of going out or studying, she improved since the last year in terms of balancing her time.
I guess I just learned about how to more balance the time, you know, and to know when to go out and when not to go out, but yeah... It’s difficult at times to actually hold a social life, but you need to make time for it, just like you need to make time to study you need to make time to have a social life. (Carol, Interview 2, October 28, 2004)

Carol pointed that her peers in the PWISEM almost did not go out at all, and that they stayed in the residence hall all of the time. She was concerned about their future success in their careers.

I realized last year living on the floor a lot of the girls hardly… almost none of the girls would ever go out, they are always there, Sunday to Sunday, all of the time, and I just feel like they are just… yeah, they are very smart, intelligent girls who are going to be someone one day, but they are not ready to face the real world at all. (Carol, Interview 2, October 28, 2004)

Other than not being able to go out often with her PWISEM peers, Carol considered her participation in the Program as valuable. She explained that her involvement in the PWISEM and especially staying together with the other PWISEM women for her freshman year helped her in her major and in adjusting to college. “Really, it was easier for me to get through the first year [because of participation in the Program] considering that you don’t know anybody and you are away from home” (Carol, Interview 2, October 28, 2004). In particular, Carol emphasized that being with others who took the same courses and who were in the same major with her were invaluable sources of aid for schoolwork and studying.

I guess it would have been harder schoolwork and stuff [if I had not been in PWISEM] because if there wasn’t someone around or next to you, [sic] would be like, “Oh, so, do you understand how to do this problem?” It just would have been, I think, a totally different experience.
[Would it have been a little harder to be in engineering if you had not been in the Program?]
I don’t think so. Maybe what it would have is being effect on it at all, just… I don’t know. It was just easier living in [the residence hall] with people that were all like in your same classes and stuff; it made it easier to study and made it easier to get work done, you know, just to get along…
(Carol, Interview 2, October 28, 2004)

Although not as involved as she was the previous year, Carol did not lose her contact with the Program and Dr. Jones. At the time of our conversations Carol was living with a few of the PWISEM women in an apartment off-campus. She also kept in touch with Dr. Jones meeting her, e-mailing her, and talking to her. “Yeah, it’s more like a mentor relationship [with Dr. Jones], not so much like personal relationship, it’s just more of like a mentor, she is just higher up and I ask her for advice in regards to school and stuff”
(Carol, Interview 2, October 28, 2004).

Carol’s Activity System in Engineering

Like last year, Carol’s primary object (see Carol’s activity triangle in Figure 5-1) remained becoming a successful, environmental engineer, working for the EPA, and possibly opening her own engineering firm. However, she did not emphasize the latter as much this year. She was excited about a new stance, becoming a politician/senator one day, which was a surprising and interesting new addition to her objects in the field of environmental engineering. Carol wanted to accomplish much in her life, which was a reflection of her active and multifaceted personality.

The contradiction between the rules with respect to the “hardness” of the field and her object had existed more strongly last year. Regardless, Carol became more confident as she learned more about her major over time. Although she witnessed high drop-out rates, her determination made it possible to get through the courses with evident

22 Throughout Carol’s case, by object, I refer to her primary object, which is becoming environmental engineer.
success. In other words, Carol resolved the contradiction between the rules and the object in her activity system of becoming a successful environmental engineer in the first place. She summarized the grounds of her success in the following way:

I balance my time out. I know when I have a test that I have to start studying a few days ahead, and I have learned not to be a procrastinator and not to leave things to last minute. When I set my mind to doing something I will do everything possible to get it accomplished. I want to be an environmental engineer and I will do whatever it takes to achieve that, right now that means a lot of studying, so that is what I do study, study, and study. (Carol, Interview 3, March 05, 2005)

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**Figure 5-1.** Carol’s activity system in engineering.
Carol also believed she improved on balancing her time in order to have a social life. She did not sacrifice all her time of social activities to studying, so from this perspective, this contradiction between the subject and the rules no longer existed. Yet, her strong sense of femininity, which was another aspect of herself as subject making her stand out of the rest, contradicted with the unstated rules of her field to appear masculine.

Carol’s dislike of her physics class because of the professor and the teaching assistant signaled the emergence of a new contradiction between her object and the university’s rules and organization. She resolved it by getting the help of a tutor, whom she found to be a more effective instructor than both the professor and the teaching assistant. The tutor became a new mediating artifact in accomplishing her object.

Another contradiction between the rules and the object was the professors’ load. Carol found it hard to contact her professors although a faculty member from the College of Engineering claimed the opposite. “Our faculty members, I think, do above the average professor in that they take time with their students to mentor them” (Dr. Ross, Interview, October 25, 2004). So, it appeared that there was a contradiction within the environmental engineering community itself; Dr. Ross thought that efficient mentoring was taking place, but Carol did not seem to be satisfied with it. What was sufficient for the faculty might not have been enough for the students at that college. The insufficient mentoring hindered Carol’s goals to some extent, which meant another contradiction between communities and the object. It was also a contradiction between division of labor and Carol’s object since the professors were not able to fulfill their roles as mentors.

Carol maintained her ties with the PWISEM community both through Dr. Jones and a few of the women from the last year. She still communicated with Dr. Jones and lived with the PWISEM women. Living in the residence hall the previous year also helped her in the coursework and made it easier to get through the first year. Thus, PWISEM became an important mediating artifact for Carol in accomplishing her object.

Carol saw social skills as one of the crucial factors in being a successful scientist or engineer. She believed making time for social life was as important as making time for studying to achieve success in a SM&E career. Thus, she was actively involved in communities of social life, which helped to enhance her interpersonal relations and social
skills, aspects of herself as subject. The communities of social life as well as the
PWISEM community contributed major role towards her object, and became involved in
the division of labor component of the activity system. On the other hand, Carol’s role as
one of the few women in the environmental engineering major became more stable as she
became more confident and still maintained her feminine style. Thus, she resolved the
contradiction between division of labor and object, which was more apparent last year.

Like last year, Carol insisted that she would “add more personality to the
[engineering] field” (Carol, Interview 1, November 14, 2003) making that the outcome of
her activity system. However, she also stated that she was not willing to work long hours
in the field or laboratory because she wanted to have family time, just like her mother, a
teacher.

As Dr. Ross indicated, being an engineer at a university was very demanding.
“Engineering is a pretty tough profession and of course there are very strict guidelines on
publishing and what those expectations are in terms of publishing in the correct journals
and so forth” (Dr. Ross, Interview, October 25, 2004). Prof. Schwartz also pointed to the
problems women faculty faced because of the demanding work they needed to do to be
able to get tenured. “We heard, yeah, ‘publish or perish,’ so the first seven years when
you are a faculty member it is like, ‘I have got to get tenure’ and ‘Where am I going to fit
the family in that period of time?’” (Prof. Schwartz, Interview, October 20, 2004). Dr.
Ross also commented that most of the time family issues for women in SM&E
represented an “either or” situation, which was exactly Carol’s concern. Other
considerations, such as those of personal life and family instead of the nature of the actual
work, influenced Carol’s decisions. For these reasons, she preferred to be a professional
engineer with the EPA, something she conceptualized as being someone who “signs off
papers in the office” for other engineers in the field and so much less demanding in terms
of time.

Even though Carol resolved the contradiction between the rules and her object
with respect to the “hardness” of the field, regarding the “male-dominated” nature of
engineering, the contradiction was still there. When considering her object, Carol had to
narrow options in the engineering profession so that she could have time for family and
be a mother. So, the culture of the engineering field as described by Dr. Ross and
experienced by Carol in the form of a dilemma reinforced that a certain type of femininity -one that includes motherhood- was incompatible with doing engineering.

In addition, Carol mentioned that she would “turn down” a job where she is required to change her style. Although she said it would not be without a “fight,” by “fight” she meant “speaking her mind” with the employer when rejected, and not meeting challenges by getting involved in the job. Given all her intentions, in spite of her determination to add more personality to the field, Carol’s tendency was towards getting a position in engineering that would allow her to be herself, and to have more flexible work hours and family time. In other words, she was less willing to try and attempt to transform the field as it currently existed (male-dominated, masculine), but would rather find a job that was more congruent with the way that she enacted her gender. Hence, her object and outcome contradicted in an evident way.

In her sophomore year, during her journey toward becoming an old-timer with respect to the new PWISEM students, Carol became more cognizant of her field as well as her quality of life in college. She was a high achiever in her courses, and still maintained her feminine style. Carol seemed to move consistently from peripheral to full-participation in engineering, given her success and determination to stay in her major rather than dropping out. However, the way she conceptualized herself as an engineer, her object, and/or as a future mother hindered the transformation of her feminine science identity as one who was capable of making a difference in the field. She neither internalized fully the culture of the SM&E fields because she retained being a “big girly girl,” nor did she seem to be ready for externalization to “make a difference” in the culture of these fields.

Lena

I’m smart, funny, a good listener…. I am an individual and a loner. I enjoy the company of others. I tend to procrastinate, but given a task that I truly enjoy, I will sit for hours on end to complete it; for example, I highly enjoy watching television and often let that take precedence over other

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23 I refer to “full-participation in the community of science” as having at least Bachelor’s degree in one of the SM&E fields, which traditionally is possible by internalizing the “culture” of the these fields (Chapter 3).
tasks. Sometimes I am serious, but I also like to joke and have a unique sense of humor. Mostly, I enjoy quoting movies with my friends and family. I am a good listener and like to be there for my friends when they need me. I enjoy being active and playing sports and attending sporting events at FSU. I am currently working at an Engineering firm and love watching something being developed from nothing. (Lena, electronic mails, March 22 and 31, 2005)

Lena’s first attempt to describe herself was very straightforward. She had mainly included aspects of her appearance, i.e., her height, eye, hair, and skin color. This first description spoke directly to her personality; it was direct, and she spoke simply and to the point. When I prompted her for a more detailed description about her personality characteristics, Lena wrote the paragraph above based on an example I provided to her.

Meeting Lena

Lena was a lot busier in her sophomore year (2004-2005) than she was in her freshman year. Thus, finding time to meet with her was more of a challenge for both of us, especially during the examination period when she was overwhelmed. Each time I met with her, Lena usually was tired and her eyes looked as though she was staying up late. From time to time, our e-mail communications also slowed down, although she was very kind and tried to do her best to be able to stay in touch with me. In each of her e-mails, Lena included explanatory details regarding her situation along with her available times to meet.

Throughout our communication and interviews, Lena continued to address me formally as she did before. She talked sincerely, and although her voice was soft she sounded sure of herself. She dressed in casual clothes, usually bluejeans and a t-shirt, and she did nothing special to appear feminine, as opposed to Carol. Her hair was always tied in the back, and I never saw her wearing make-up. Lena appeared like a typical woman engineering student.
Overcoming the Academic Obstacles

In her sophomore year in the civil engineering major, Lena’s goals remained the same, which I included in Chapter 4. She wanted to be a civil engineer and work for an independent firm on a private scale. Although her interest was still high, Lena’s confidence in pursuing civil engineering went down since she was experiencing difficulties in her core courses, physics and calculus. This was quite an astonishing situation since Lena had talked last year about how much she enjoyed her science and mathematics classes and how easy they were for her. Lena explained the reason in the following way:

Well, the difference between high school and here was… I was always advanced in classes and so I was always like… I already knew it sort of… and when I got here… It was really, really new stuff, it was really out there to learn, but I am getting it now. (Lena, Interview 2, October 28, 2004)

In her first year, Lena lived with the other PWISEM women on the same floor of a residence hall, so during that freshman experience it was easier for her to get support for her courses.

All girls could sit in the lobby and all do homework together because you all have the same classes… All girls, we took chemistry and we studied chemistry together. I know they helped me out as well as I helped them out. (Lena, Interview 2, October 28, 2004)

In this interview, Lena acknowledged that “it would have been too easy to drop the classes” had she not been involved in the Program. Especially, living together with other women in the SM&E fields during her first year was extremely helpful for her to achieve success in her courses. In other words, the Program was helpful for Lena in terms of academic support. Although not able to attend the events organized by the Program in her
sophomore year, Lena maintained contact with a few of the PWISEM women, one of whom was Carol.

In the first semester of the 2004-2005 academic year, Lena had the same physics course with Carol but they were in different classes and had different professors. “Physics… but the thing with Physics is, it is such a big class and it was just a lecture and it is hard to get one on one…” (Lena, Interview 2, October 28, 2004). Even though they were in different classes, both women talked about how large and overwhelming the physics course was and how that hindered their learning because it was lacking opportunities for cooperative or interactive learning (Cronin & Roger, 1999) and was too impersonal (Seymour, 1995). However, unlike Carol, Lena came to a point where she almost gave up. Not doing well in her core classes, for the first time in her life, made Lena seriously think about dropping them.

The “want” to be in the major is still as high as before, the interest is high but the doubt of the ability is coming like… with the Physics and Calculus classes I was like, “Man, can I really do this?”

I went through a bad week, you know, “I am dropping this, I am going to something else, I cannot do civil engineering” but… (Lena, Interview 2, October 28, 2004)

Two factors were very influential in Lena’s decision not to give up and to continue to pursue civil engineering. One of them was the internship she had with a private engineering firm, and the other was the support of her family and friends. Lena was still working in the firm, in which she interned, and she enjoyed this work. Her job was a driving force for her to stay in the major because it represented a more realistic image of her field. She uncovered that being successful in engineering takes more than academics.

… But since I have had the job, I have been working with engineers and doing their work, too, so I know what they use and all those physics and
math stuff… it is not all they use, you know, so I am like, if I can get through this I will be able to do it.

So, you can see the big picture, it is not all physics and calculus, it is different and you can do that. (Lena, Interview 2, October 28, 2004)

Too, the support of family and friends was very important for Lena. Although she had confidence in herself that she could succeed, it was not high enough to keep her in the major. Lena expressed herself in the following way:

I just needed to have somebody to let me know, “You can do it; it’s possible.” Give me a little kick in the bottom a little bit to say, “Hey, wake up, you can do this. It is not a big issue.” (Lena, Interview 2, October 28, 2004)

Lena had her parents’ support since her childhood, as I also mentioned in Chapter 4.

Yeah… both of them are very supportive because my parents, like, my dad didn’t go to a college and my mom only went to three years. So, they really have high expectations and so, they are always there. Just to make sure that I can do it. I can focus on my one. It doesn’t matter to them if I do engineering or if I do communication or if I do education. It doesn’t matter to them. They just want me to be happy and to do what I want to do. (Lena, Interview 2, October 28, 2004)

At the time she was struggling Lena had their support as well as her other relatives’, friends’, and her physics professor’s. The encouragement of these people was the “kick” she needed.

It was my parents [who supported me]. Like, before drop of classes I had a bad feeling; I don’t know if I can do it. I always had my family. My
parents, my brother, and my cousin in California, who heard I was having a little trouble. She sent a card in the mail that said, “You can do it.” I went and talked to my professor and he told me, “I can do it.” One of my roommates supported me… [She was] very supportive of me. She was like, “Look, if you want, you can drop it but I think you can do it.” (Lena, Interview 2, October 28, 2004)

The support of the people close to Lena had a significant meaning to her. “[My family’s and friends’ encouragement] worked to me. Now, I am studying really hard and am getting through it.” (Lena, Interview 2, October 28, 2004) Lena’s experience supported Dr. Ross’ comment on what made a college student successful.

What makes a college student successful is that they find one person, one professor… one person that they can really relate to and that person gives them the encouragement, the drive, the motivation to continue their pursuits to become an engineer. (Dr. Ross, Interview, October 25, 2004)

As Lena mentioned, her physics professor in the first semester was very helpful. She went to him for advice on how to succeed in his class and they decided on a working schedule together. He also made it convenient for her to call and reach him whenever she needed. She went to his office twice a week to get help. “Every Tuesday and Thursday I go in there and we work on problems and break stuff down” (Dr. Ross, Interview, October 25, 2004). However, Lena did not think her physics professor in the second semester who had been Carol’s professor in the first semester, was helpful. Lena also did not find it easy to talk with her calculus professor. “The calculus teacher, he does not look very approachable, he is kind of scary but I am getting into it right now… he just looks like, as a matter of fact, ‘You need to know this already’ type of thing…” (Lena, Interview 2, October 28, 2004). By “I am getting into it right now?” Lena meant “I am getting into the class, starting to understand a little bit more, I had found my groove and my niche” (Lena, Interview 3, March 22, 2005). However, Lena unfortunately could not pass the calculus course in the first semester. She took it in the second semester, as well,
with a different professor whom she liked better. She commented that her failure in the first semester was possibly due to the professor not being understandable and helpful.

In contrast, Lena enjoyed her engineering classes, and they were not as difficult for her. She was especially good in the sketching classes. She attributed her success in this specific class to her ability to observe something and sketch it. “That comes naturally to me, like, being able to sketch” (Lena, Interview 2, October 28, 2004). She had good relationships with her men peers, and she was actually helping them in these classes. “A lot of them actually are asking me for help in their homework and stuff” (Lena, Interview 2, October 28, 2004). Interestingly, Lena pointed that it was easier to approach her men peers than her women peers in engineering. She had more men friends than women.

I usually try to talk with people and whatever but a lot of the girls, they do not talk to me, like, there is one girl in my engineering class. I would ask her a question she would just answer the question, nothing more and… that is like how it is like with a lot of the girls, you say, “Oh, do you have a lab due today?” and they are either like, “Yes” or “No” and that is it. But I talk to the guys in the class a lot easier than I talk to the girls, they all come and sit with me and talk with me and… (Lena, Interview 2, October 28, 2004)

Lena also commented that the men bonded easier than the women in her major. She had a remarkable explanation for that.

It seems like the men bond quicker than women do in engineering classes. Like when you go to a class, they all say ‘hi’ to each other even [if] they don’t know each other. And, women usually just tend to sit there, quiet, and watch… I don’t know maybe they feel that they have to guard themselves because of the male-dominated thing. ‘I have to get to this; I have to do this’ instead of like… Yeah, ‘I can do it, I can do this,’ trying to prove… if she is trying to prove herself too much then that also might be the reason why they stand off… [it] is if you are like, ‘I can do this, I am
going to prove to all these guys that I can do it.’ They do not really gather together and do like, ‘All right, girls, let’s prove these guys wrong.’ They do not… girls usually do not do that, they really tend to think, ‘I can do it.’ The girls, I think, are more independent when it comes to their career and stuff than men are, because there is [sic] a lot of guys that do the whole group thing and, I do not know, girls are just weird creatures… (Lena, Interview 2, October 28, 2004)

In other words, Lena speculated about her peers’ rationale for behaving that way. She thought that maybe they believed connecting on a personal level with the other women in the classes was inappropriate because it would signal a certain form of femininity that was more in conflict with the masculine norms of the course. So, their motive for remaining disconnected might have been to prove that they really “belonged” to the field, as Lena implied. According to Seymour (1995), “‘proving yourself’ by standing up to the weed-out system is important in establishing the claim to adult masculine status in these disciplines” (p. 461).

Lena also mentioned that there were noticeably less women faculty than men faculty in the physics and engineering departments, as is supported by Dr. Ross’ comments. She also said that in the firm she was working 16 out of 20 engineers were men. According to Lena “[science] has always had that masculine connotation” (Lena, Interview 2, October 28, 2004). She believed there was more sexism than racism in science. She did not think that “the color of a person’s skin was that important in science anymore” but she thought that “the gender thing was still an issue; men that were higher up in the fields still had the belief that women still could not do as well as men could” (Lena, Interview 3, March 22, 2005). Moreover, Lena mentioned that the masculine connotation was all over the scientific field; androcentric and ethnocentric biases were present in scientific practice and products (Bianchini et al., 2001).

Well, because of all of professors and everything you hear about… science in high school… it always felt masculine because of all the equipment they use, it is more of a masculine thing like… The stuff they use to do
labs and stuff… to do physics labs they… the type of materials they use, like the rod, stuff that… does not feel feminine; it is all like masculine… (Lena, Interview 2, October 28, 2004)

The reason “it did not feel feminine” was that girls, beginning from early ages did not have as much experience with mechanical objects as boys did (Jones et al., 2000; Kahle & Lakes, 1983). Physics teachers often are not aware of the gender gap and “know very little about classroom behaviors and educational means that can eliminate the problem” (Zohar & Bronshtein, 2005, p. 74). Nevertheless, it is possible to enhance girls’ interest and achievement in physics by developing an interest-guided curriculum for girls (and for many boys) replacing the traditional scientific tools and practice (Häussler & Hoffmann, 2002).

Lena’s observations spoke to the culture of the community of science as men-dominated field. However, Lena was hopeful that as more and more women participated in science that the masculine connotation would change. So, the change she was talking about was related with the number of women who participated in science. Moreover, according to her it did not matter if the women in her major bonded or not as opposed to Liss, Crawford, and Popp (2004) arguing collective action; according to Lena it was enough if the women remained in the engineering field. Lena believed that the number of women scientists was increasing. She also thought that as more women became scientists, there would be more role models for girls and young women who wanted to become scientists but were hesitant.

It is important that women become scientists because there is [sic] a lot of girls that need… that are little… that do not know if they could do it, you know, and they need some good role models and… Like, my role model was a woman engineer, from my home; she was my brother’s godmother and my mom’s best friend in college. And she actually got me the internship this summer, and through high school she was my influence a little bit. And it is important to have female role models because girls, in certain societies girls are like, “Oh, you are a girl, you need to be
homemaker,” still to this day, and it is not entirely true, and they need the role model and… (Lena, Interview 2, October 28, 2004)

Dr. Ross made the same emphasis with respect to role modeling: “We are probably not getting enough role models into the schools… to work with girls. To say, ‘I did it, I am the woman, I am a scientist’” (Dr. Ross, Interview, October 25, 2004).

In addition, Lena believed that women would bring a different point of view into science. Emphasizing that she talked about stereotypes, Lena commented:

Typically guys are more stubborn and they see one thing, they want to do it their way and that is how it is going to be, and girls tend to be… to look at something that they cannot figure it out, they back off and then they look at it and go out and try a different view and try it in different way…

They [women] will come up with different ways of doing things and it will show in the experiments and life and the way things are… (Lena, Interview 2, October 28, 2004)

In other words, Lena saw connections between gender and epistemology. She suggested that women might, in fact, be better at some aspects of doing science since they could look at things holistically and from a unique perspective, which implied a feminist standpoint epistemology like Harding’s (2001) and Haraway’s (1988). Indeed, Newton (1986) argued that “female scientists and engineers are different from their male colleagues, and they bring a different perspective to their work” (p. 57).

Lena saw the SM&E fields as men-dominated, but she did not see any relation between men domination in terms of numbers and the gendered culture of these fields. She was seeing the possible benefits of adding feminine perspectives, but was not arguing against a predominantly masculine perspective that was the norm. Lena saw scientific practice in gender-blind ways, and this opposed her statement about scientific tools and practice having masculine connotations.
Lena also indicated that there were certain characteristics that a scientist needed to have in order to be successful, but she did not think these characteristics needed to be of a certain gender, or masculine per se, just like Dr. Gordon thought. “I guess I am not the person who really notices the gender inequity problems. Because I always believe people just achieve what they want to achieve based on your ability. It is not based on your gender” (Dr. Gordon, Interview, November 16, 2004). Lena emphasized problem-solving skills and the ability to look at a problem from different angles as the most important skills that a scientist would need. According to her, that was merely a personal matter. “Like, I just know that I want to do a job and I will do it. It doesn’t matter if I am male or female. If someone tells me I can’t do it I wouldn’t approve” (Lena, Interview 2, October 28, 2004). Her assumption was that success was defined purely by skill and effort, ignoring structural problems in the SM&E fields. It was an apolitical view of science and gender as opposed to radical feminists’ view of patriarchy as “a system of domination which pervades all aspects of culture and social life and which is to be found in all cultures and at all moments of history” (Weedon, 2000, p. 20). Apparently, Lena (and also Dr. Gordon) bought into the tenets of the American meritocracy equalizing academic performance to merit and not taking into account factors such as parentage, background culture, class, and also gender, influencing one’s academic success (Lemann, 1999).

However, Lena also had previously stated that stereotypically, women would bring a different point of view in science because they “back off and then… look at [the problem] and go out and try a different view and try it in different way” (Lena, Interview 2, October 28, 2004). She also added that a good scientist was one who had the ability to look at problems from different angles, a feminine characteristic. By mentioning women scientists’ different point of view than men, Lena implied a certain culture embedded in science, which was masculine, and contradicted her previous comments about science being gender neutral and about success in science as being merely a personal matter.

Lena was involved in a social organization, Spirithunters. She wanted to have a social life. “Too much school, too much work, you need break” (Lena, Interview 2, October 28, 2004). It was an active organization, in which they went out and painted the faces of the members of “all the teams and bands… at all of the sport and university events” (Lena, Interviews 2, 3, October 28, 2004, March 22, 2005). From time to time,
they went out of town to see football games together. This organization was an important part in Lena’s life. It helped her take a break from her classes and develop social skills.

*Lena’s Activity System in Engineering*

Since the last year, Lena’s *object* (see Lena’s activity triangle in Figure 5-2) remained as being a civil engineer and working for an independent firm. She actually hoped that the firm, in which she had internship, would hire her after her graduation. She liked her job in the firm and wanted to work with them. Lena’s long-term goals included solving problems in her expertise area and bringing different solutions. “I want to work, like, road raising stuff. I want to solve the problem of crowded streets of too many accidents, make driving and traveling easier” (Lena, Interview 2, October 28, 2004). This was her *outcome* of being a civil engineer. Lena made less emphasis than she did last year on “change” in science as the participation of more women to reach equality with men (Lena, Interview 1, November 12, 2003), a liberal feminist approach (Rosser, 1997; Scantlebury, 2002; Weedon, 2000). Instead, she emphasized more the role modeling women scientists would provide to girls and young women (Wygoda, 1993).

During our interviews, Lena made competing comments on the relationship of science and gender. Although she argued that scientific practice was not gendered she also mentioned that scientific tools and practice had masculine connotations. Again, while Lena indicated that there were some characteristics that a successful scientist needed to have and that these characteristics were not gendered, she mentioned that one of these characteristics was the ability to look at problems from different angles, sometimes considered to be an essentially feminine characteristic. Lena’s arguments about the relationship of science and gender signaled contradictions within her own thinking, the *subject*. 
As a sophomore, Lena experienced a major contradiction between the *rules* and the object in her activity system. Although she was very confident of herself in pursuing civil engineering last year and she enjoyed her mathematics and science courses a great deal, this year she felt less confident because of her struggle with core courses like physics and calculus. Her failing the calculus course strengthened the contradiction even more. These courses as *mediating artifacts* also formed a contradiction with Lena’s object, which she needed to resolve.

The contradiction between the rules and the object brought about a simultaneous one, which was within the subject herself. Lena lost confidence in herself of being in civil engineering, although she was far from such an issue last year given her statement that there were not really many barriers that would stop her from pursuing her major. She was
disappointed by her academic standing since she had been a very successful, top ranking student in high school but this standing changed dramatically in college.

The resolutions of both of the abovementioned contradictions were possible with two very important factors, or mediating artifacts. One of them was the internship, or the job Lena had with a private engineering company, and the other was the support of her family, friends, and professor. Her parents, cousin, friends, and her physics professor fulfilled their role in Lena’s activity system as supporters, which signals that division of labor took place efficiently within and between the communities of family and friends, academic major, and the PWISEM community (since she was still in touch with several of the PWISEM women). However, it is important to note that the poor relations among the women in her major represented a contradiction in the division of labor within the academic major community, which would otherwise be another academic support.

Although her physics professor in the first semester was very supportive, the same was not true of her calculus professor and her physics professor in the second semester. Lena especially found the calculus professor distant and not willing to help.

I did not understand what he was saying and I would just nod my head. His explanations went over my head and when I would ask for a breakdown he would look upset and just be like, “You guys should know this already.” I also could not make it to his office hours and he did not have time to meet with me any other time. (Lena, Interview 3, March 22, 2005)

By not fulfilling their role as advisors, the calculus professor’s and the second physics professor’s attitudes led to a contradiction between the division of labor and the object of Lena’s activity system. So, last year’s contradiction between the rules and Lena’s object narrowed down to being a personal issue and not a general one stemming from the university rules and organization deciding for the professors’ (over)load. Although the first physics professor spent time with Lena to help her with her coursework, the calculus professor was not as eager to do so. Lena believed that the calculus professor just was not concerned about his students’ failure or success. “I just
think one cared for his students and wanted [us] to succeed; maybe my physics professor did not want to see his students give up, and I do not think my calculus professor cared at all” (Lena, Interview 3, March 22, 2005).

Lena enjoyed being in the civil engineering community. Although she was one of the few women in most of her classes, she could get along well with her men peers and this situation did not represent any contradiction. In fact, it was not possible for her to have close relationships with her women engineering peers. This was a notable contradiction between the community of Lena’s academic major and the division of labor component of her activity system, which conflicted with a possible outcome of “changing” the masculine connotation of the SM&E fields since such a “change” would require collective action, or activism (Liss et al., 2004).

An important discovery of Lena’s was that the women in her major acted purposefully in unusual ways. She found that the women in her classes tended to be more individualistic and less personally interconnected than the men, who bonded easily together. Lena’s explanation revealed that the culture of the community of engineering implicitly demanded certain women behaviors that differed from those of men’s. Being an inconsistency, this situation represented a contradiction in the civil engineering community; according to Lena women felt a need to behave in certain ways because they were in engineering. Such a tendency troubled the sense of community and left room for criticism.

The role of the PWISEM in Lena’s activity system was a significant one. It was a very important community in which she belonged, and also a powerful mediating artifact toward her object. In her first year at college Lena got the academic support of her peers in the Program and was able to overcome the obstacles she faced in her courses. During her freshman year of living in the community, she did not drop a science class, nor did she even consider such an action. This was in contrast to her views in her sophomore year. It was evident that living together as a community had had a very positive effect on Lena’s achievement and retention in the major.

At times Lena experienced difficulties on her path of becoming an old-timer with respect to the new newcomers in the community of science. Her struggle in the courses slowed down her progress from peripheral toward full-participation. She seemed to make
an effort to internalize the culture of the SM&E fields by working hard to be very successful in her major. The internship had reinforced the internalization process since it provided Lena with access to more authentic language and cultural practices of SM&E. She did not seem to experience externalization, though. Lena was headed towards full participation in SM&E as a typical engineer but she had the awareness of being a role model to girls and young women, as well.

Reyna

I love to hang out with my friends, meet new people, and generally for there to be people and movement going on around me. I'm very close to my sister who is graduating this year with a biology degree of her own. I used to be shy but when my sister left for college I had to start being more outgoing and "find myself." So I have found that I love music and hanging out. I am sarcastic a lot and I love joking around, I really am not that good at being serious. I also do procrastinate with my school work but I'll get it done eventually. I love God and want to live for Him everyday - can't wait to be with him in heaven. That's about the gist of me, God loving, music crazy, and sometimes studious person. (Reyna, electronic mail, March 03, 2005)

Like Carol and Lena, Reyna also wrote her self description upon my request during a member check process. It was an intense summary of herself that was very clear and delineated what I understood to be the core aspects of her personality.

Meeting Reyna

After our last conversation during the previous fall, I reunited with Reyna at the awards ceremony of the PWISEM in the fall semester of 2004. Reyna exhibited the same shy and polite personality, which she also mentioned in her self description. She almost always smiled; her voice was soft and she spoke with obvious care evidenced in her voice. As she stated in her self description, Reyna had a strong sense of religion.

Like the other two participants, Reyna was a lot busier than the last year. At the ceremony we had a quick conversation, and part of it was personal. Reyna asked me to e-
mail her whenever I would like to meet her for an interview. Our first meeting was not easy to arrange, though. Although I e-mailed her several times, not hearing back made me wonder if she was still willing to participate in my research. Eventually, Carol helped me to get in touch with Reyna, since these two PWISEM women maintained their bond by living in neighboring apartments during their sophomore year.

Making a Decision: Biology or Anthropology?

Reyna was still interested in her major, biology, and her confidence in pursuing it was even higher than the last year. She explained the rise in her confidence as being due to the fact that currently she knew more about biology, whereas previously it was an unknown for her. She learned more about studying techniques, too.

… For the first test I was really like, “I don’t know, how do I study?” because it’s not like math and chemistry where you just do the problems in the back of the book and stuff, but biology is different, you just memorize it, you just memorize, “Okay, this is how such and such works.” You can’t do problems out; there is no math really involved. (Reyna, Interview 2, November 06, 2004)

However, Reyna seemed confused about what she wanted to do with her biology degree in the future. She found many of the subjects in biology uninteresting and not appealing to her.

Actually the test that’s coming on Monday is I think going to be the most difficult for me, because it’s on the human genome and stuff, and I know genetics is cool and everything but personally I’m not interested in it. And, you know, DNA augmentation and changing… splicing and trying to put, like… rabbit DNA and spider DNA and mixing the two and seeing if it works. I don’t want to do that. (Reyna, Interview 2, November 06, 2004)
Reyna emphasized that she was mostly interested in animal diversity and being a veterinarian. Having said that, until the second semester of her sophomore year, Reyna was not sure if she really wanted to stay in biology or switch her major to anthropology, in which she lately had become interested. She narrowed down her interest to being a veterinarian, but knowing that getting into the veterinarian school was challenging was a factor that made Reyna think about pursuing an anthropology major.

I was taking a chance to get to anthropology… Well, I’m still thinking about it, like, I’m going to take an archeology course this semester, and hopefully will decide, because I really liked cultural anthropology and archeology. So, archeologists… you know, more scientific view of that, use scientific method and stuff, like experimentation and procedures, getting the bones and whatever, collecting data, and doing… lectures… data of fossils and stuff and then… When I took… in my anthropology class last year, I just really enjoyed it; it was a lot of fun. (Reyna, Interview 2, November 06, 2004)

She was fascinated by the anthropology course she had taken as an elective for her biology major. She saw anthropology as “a different kind of science” (Reyna, Interview 2, November 06, 2004), in which scientists collected data, performed experiments; in short, used methods of science. Interestingly she saw more aspects of scientific work in anthropology than in biology, but possibly that was a reflection of her seeing learning biology as merely memorization of facts.

Reyna experienced some difficulties in her core courses in the major, but that was not a major issue for her. According to her the professors played a great role in making the courses hard. In our second interview on November 06, 2004, she mentioned how some of her professors were effective science teachers and some were not. “Chemistry is okay, but not as good as last year.” She mentioned how her professor in chemistry was a good teacher for Chemistry I, but that did not hold true for Chemistry II since “he has never taught Chemistry II before.” She depended on the recitation hours to better learn chemistry, but she had to go to another TA’s since she did not care for the one to whom
she was assigned. On the other hand, Reyna was pleased with the way her biology professor taught biology. “Biology is good. He is very thorough.” Reyna also mentioned her calculus professor. According to her he was not “good” because he was a TA and did not have experience in teaching.

If you get TAs, chances are they are probably not as good as a teacher just because they are new in everything and they usually just write the course notes on the board, which is exactly what he is doing. And so, there is no point coming to class. (Reyna, Interview 2, November 06, 2004)

Reyna had to get help from a tutor for her calculus course. She explained: “And my math stinks. I should teach myself, but that’s okay. I have a tutor and so, my tutor is really good” (Reyna, Interview 2, November 06, 2004). Reyna’s calculus tutor was one of the tutors funded by the PWISEM.

At first, Reyna feared the most the upcoming organic chemistry courses, which she would start taking in the spring semester. “Yes, it is kind of scary; they [my peers in the PWISEM who already took organic chemistry, my older friend and older sister who are majoring in biology (Reyna, Interview 3, March 03, 2005)] even tell us horror stories, so that’s going to be an adventure” (Reyna, Interview 2, November 06, 2004). But after taking the first organic chemistry course, she was relieved. “The [organic] chemistry class was not as bad as my friends had made it out to be, it is not a piece of cake but as with anything, enough work and studying will get me through it” (Reyna, Interview 3, March 03, 2005). Despite her concerns and anxiety related with the coursework, Reyna seemed to be doing very well in terms of maintaining her GPA.

Reyna acknowledged that she might have been hesitant to approach her professors for help. Prof. Schwartz had exactly the same observation with the women undergraduate students in the department.

[Women students] do not really talk to [the faculty], [women students] do not approach [faculty] with problems related [to] courses as often as the male students do, and I do not know, and this could be, you know, they
just feel intimidated about them or they are just shy or they wait for a male student to ask… (Prof. Schwartz, Interview, October 20, 2004)

Reyna related part of her hesitation due to her professors being distant, and part of that she thought was because of all of them were men.

Mr. Brown [the chemistry professor, pseudonym] I think is definitely more distant. I would try going to my TAs and stuff first and trying to [inaudible] them to get to him… I did [go to him] once and I was really nervous, I know I was asking him about a quiz and then I didn’t get the answer I wanted to but I was just like, “Okay,” and I just walked out.

I would think that would be true [that I’m hesitant to go to the professors]. I actually don’t have the female professor, it don’t [sic] exist for me right now, but I think if I did have one I probably would be more confident going and talking to them. (Reyna, Interview 2, November 06, 2004)

As Prof. Schwartz explained, in the biology department there were seven women faculty members out of 50, and 36 women graduate students out of approximately 85-90. “At the faculty level I’d definitely say [we are] very male oriented and male-dominated… our department has disproportionately fewer women” (Prof. Schwartz, Interview, October 20, 2004). Such a distribution contributed to Reyna’s uncomfortable feelings in the major; she did not feel comfortable going to her professors, all of whom were men.

Reyna also mentioned her calculus professor’s attitude toward one of her women peers in the class. She explained that she had never noticed such an attitude toward a man student and that it made her feel uncomfortable approaching this professor.

[Have you had any personal experience about professors looking down on you as a woman?]

No, it was how he responded to somebody in class. There was this girl asking a question and he was just like, “I don’t know how don’t you get
this, it’s so easy.” I guess he was probably just frustrated because he didn’t know how to explain it to her, but it was just like, “Stupid, why don’t you get it?” (Reyna, Interview 2, November 06, 2004)

Ironically, her last year’s mathematics professor was very helpful to her. As she had described him, he was caring and supportive, something that she had not expected from a typical college professor who would be too busy with his schedule to help students outside of class.

Remarkably, Reyna’s consideration of changing her major was mostly due to the fact that she did not want to be a biologist like her biology professors. Her university experience provided some insights into who biologists are, and she found them lacking. In other words, she did not see them as good role models.

My biology teachers and everything are so boring to me. I mean, he is so boring, like, he told us this DNA thing was his specialty, he was… excited, he said, “Yeah, guys, I really like this one.” And he is like… puts me to sleep every class even when he was excited about it. I’m like falling to sleep trying to write, it’s terrible, it really is… I was like, “I don’t want to be that.”

… They just seem more as being like [inaudible] and not having much of a personality. He definitely fits that. He doesn’t really seem to have much of a personality. And he is a really good biologist… That is, I think, definitely the image [of a typical scientist]. (Reyna, Interview 2, November 06, 2004)

On the other hand, Reyna loved her anthropology professor and was excited to be like her. “I liked her. She was cool. She was very exciting” (Reyna, Interview 2, November 06, 2004). Her being a woman was a very important aspect that influenced Reyna’s thinking.
… If I saw a male teacher into it and more exciting, I would like it, and if I saw a female one who is more exciting into it, I would like it, too, but I would like it… I think, she would make more of an influence on me probably than him, just because I could relate better to her, her being a female and everything. I would be like, “Wow, look at her,” and the guy [may say] “that would be cool,” [but] I would be like “Wow, that’s cool!” but I could still relate better to her. (Reyna, Interview 2, November 06, 2004)

She was also thrilled by the course itself. “So, in anthropology, I think, it’s a lot more, I guess, exciting, like, easy materials to be excited about, I guess, like, show emotion towards” (Reyna, Interview 2, November 06, 2004). So, unlike her biology classes, Reyna found that this class valued and supported emotional investment. It was evident that she looked for certain aspects in her major and future career such as excitement and being able to enjoy her work. Yet, Reyna eventually decided to keep her biology major. Her decision was primarily based on her taking the organic chemistry course and the more advanced biology courses and achieving them.

At first, Reyna’s uncertainty about her academic major had evidenced itself in her future goals, too. In other words, what she wanted to do depended on which major she would choose. If she stayed in biology, she wanted to be a veterinarian or a paleontologist. “Yeah, I guess I want to be just a veterinarian, or completely different, a paleontologist. Like, those are the two areas and biology major, that I am interested in” (Reyna, Interview 2, November 06, 2004). If she switched to anthropology, she wanted to stay in academia and become an anthropology professor, just like the professor she had in her anthropology course. What Reyna knew for sure was that she did not want to be a professor in biology.

In the second semester of her sophomore year, Reyna decided to continue pursuing biology and be a paleontologist. “In my biology class I enjoyed paleontology the most, so I am going to make it my goal to be a paleontologist” (Reyna, Interview 3, March 03, 2005). Specifically, she enjoyed learning about animals. When she compared being veterinarian to being paleontologist she made an interesting justification of her
decision: “I still learn about animals - except they are dead. I do not want to have to hurt live animals even though I know it is to help them” (Reyna, Interview 4, March 18, 2005). With this statement, Reyna exhibited a deep caring attitude, considered stereotypically a feminine characteristic (Bem, 1974), also attributed by girls to biology as discipline (Jones et al., 2000).

Reyna was not alone in her decisions. Whatever she wanted to do, she had always had her parents’ support. “They never pushed like, ‘Do what is money!’ They will say to find what I love and make it a job. So, I’m like, ‘Okay, that’s what I like’” (Reyna, Interview 2, November 06, 2004). Reyna involved her parents in the brainstorming of what major to choose. She discussed with them her intentions, concerns, career options, and her final decision.

I talked to my parents over spring break [2005] and really thought about how far I have already come - what I have left to do - and if I think I could really enjoy having a biology major. (Reyna, Interview 4, March 18, 2005)

I feel confident with this decision [to be paleontologist] and my parents support me. (Reyna, Interview 3, March 03, 2005)

Reyna thought that most women would not want to be professors in the SM&E fields just like she felt. According to Reyna, the reason of women’s hesitation was socially accepted stereotypes, which portrayed women as being good in verbal skills and men as being good in science and mathematics. Reyna indicated that women and men had acted in these stereotypes for so many years but recently that started to change. However, she was also aware that equality in terms of the number of women and men teachers was more evident in high schools than at college level.

I mean, it started from when women couldn’t even have jobs and they stayed in the household and then started striking out, getting jobs and stuff, but there was still more like, they are dealing with children, teaching English and stuff and they were… you know, high school still… teachers
say, and SAT and stuff, girls will do better in English and guys will do better in math. (Reyna, Interview 2, November 06, 2004)

Reyna did not think that was the case, she pointed that it was a “nature versus nurture” issue, and that the difference between men and women existed but it was more of an outcome of “nurturing.”

Oh, that’s the trend right now, so I believe, I mean, the facts are there. But, I don’t think necessarily that may be because we can’t do as well as guys, or guys just can’t read or understand stuff as well as us. I don’t think that’s the case, I think it’s just they are pushed more… they gave them erector sets and stuff when they were kids, you know… It’s still the whole nature versus nurture thing; it’s still nurtured for them to be better in math and science, and for us to be better in English and stuff. (Reyna, Interview 2, November 06, 2004)

Reyna mentioned that the reason there were less women than men in mathematics and science was that women were raised to be “more infiltrating” and fear the “math thing.” By “infiltrating” Reyna meant that a woman was raised “to be read more into comments and conversations etc., almost like a reporter, and understand people” (Reyna, Interview 3, March 03, 2005). According to Reyna in society women were seen as people with whom to talk about problems, and not as mathematicians or scientific researchers. Prof. Schwartz also thought that women feared mathematics. Reyna thought that since there was not much mathematics involved in biology there were a lot of women in this field. Men tended to go into more mathematics-based fields like physics, chemistry, mathematics, and engineering, and women tended not to enter those fields.

And even if in the actual medical school, if it’s pretty much equal, I think, probably there are more males who are going to be doctors and more females who are going to be nurses. That’s what I think. I mean I guess we
Reyna mostly talked about equality in terms of numbers. She did not think much about the culture of the community of science in terms of gendered components. According to her, scientists needed to have certain characteristics to be successful, but she did not attribute these characteristics to a certain gender.

[In order to become a scientist do you think there are certain characteristics that you will need?]
Well… don’t know where to begin… I mean, you’d have to be, I guess, like, responsible, and dependable, you know, and you’d have to know what you are doing and be able to cope with the proper experiment and be able to back up with everything, do research and you’d have to definitely be so organized. You never do it to look organized to other people, you’d have to understand your own system that you make, because there would be so much information running around, or you would have to get groups to be able to do it together, and other stuff, you’d have to be organized for it, too. I think you’d have to be pretty much a leader, too. (Reyna, Interview 2, November 06, 2004)

Since last year Reyna learned to balance her school and social life better. Although she was busier because she was involved in a sorority, she was doing very well in her courses. She learned how to communicate her priorities to the members of the sorority, and still to remain pretty much involved. She was even willing to have a position in the organization. Reyna was sure that it would not interfere with her academic responsibilities. “Yeah. Technically, yes, [I will become busier], but it’s because… I think I started to get handle on this” (Reyna, Interview 2, November 06, 2004). Being in the sorority was very important for Reyna as it was part of her real life experiences.
Reyna enjoyed her PWISEM experience, too. She liked living with women from SM&E majors last year since it was helpful to get through courses. Reyna also mentioned
that being in the Program helped her narrow down her options in terms of her future career.

Oh, I think it [being in PWISEM] just showed me my options better because speakers came in from different areas of science, you know, and they came and talked to us, and I went to the Colloquium, actually to the ones I was interested in, and they helped me, I guess, narrow down what I wanted to do with biology, if I go into biology, you know. (Reyna, Interview 2, November 06, 2004)

As a sophomore in the academic year 2004-2005, Reyna volunteered to be a mentor for the new students in the Program. In PWISEM being a mentor meant helping the new students one on one so that they adjust easier to college life and to their majors.

I will help her with her classes and stuff and choosing her professors, and if she needs help finding a tutor or that kind of business, but I think also I would help her just adjust to being in college, like, if she was feeling homesick she will find me as someone to talk to, you know, that kind of issue, too. (Reyna, Interview 2, November 06, 2004)

Reyna’s intention to be a mentor and help freshmen was an indication of her caring personality and her strong ties with the PWISEM.

Reyna’s Activity System in Biology

In the midst of her sophomore year, Reyna’s object (see Reyna’s activity triangle in Figure 5-3) narrowed down to being a paleontologist although until that time she considered switching her major to anthropology. She had a number of reasons to consider switching. First of all, Reyna had found many of the courses in biology uninteresting and unappealing to her. Relevantly, she did not want to be a biologist like her biology professors because she could not relate to them and found them lacking and impersonal. The only area she would want to go in biology was the veterinarian school and she
thought it was too challenging to do so. On the other hand, Reyna became fascinated with anthropology through a course she had taken as an elective, and she loved her anthropology professor.

At that time, she felt excited to be like her anthropology professor. Eventually, Reyna made up her mind to pursue paleontology, which also dealt with animals, and which was not an academic career in biology. Reyna was delighted to have made her final decision concerning majors: “I am extremely excited to have made up my mind…” (Reyna, Interview 3, March 03, 2005). Her outcome in becoming a paleontologist was “just to find something she loved and make it her job” (Reyna, Interview 4, March 18, 2005).
In her sophomore year, Reyna did not enjoy some of her science courses. She argued that the basis of this lack of enjoyment was the way the professors taught them. So, she was forced to seek help from tutors, and these tutors became *mediating artifacts* toward her object. In fact, Reyna was not comfortable approaching her professors for help since they were men, and as she described them, “distant.” This situation could be attributed to the men-dominated nature of the SM&E fields. Thus, a contradiction between the *rules* and Reyna’s object was unavoidable. Reyna’s intention for resolving this contradiction was to seek help from tutors like she did before. Her awareness of the men dominance, and her determination were also important factors that were preparing her to meet challenges.

I know my teachers will more than likely continue to be male, especially as I will be taking physics next semester. However, I am going to try my best to suck up any discomfort I may have with them and get extra help when needed. (Reyna, Interview 3, March 03, 2005)

Nevertheless, Reyna considered the field of paleontology as less men-dominated. For paleontology, she needed to go to graduate school and at least obtain a master’s degree. “I don't think it is really male-dominated. There may be a few more men but I know there will be good women role models in that field, as well” (Reyna, Interview 4, March 18, 2005). So, she was comfortable in terms of finding women role models whom she did not have for the time being. However, the statistical information provided by NSB (2002) and NSF (2000) about women earning bachelor’s and master’s degrees in earth, atmospheric, and ocean sciences –although there was no specific information about paleontology- shows that women are underrepresented in these fields (i.e., 37% women earned bachelor’s degree in these fields in 1998), as well. Also, after my personal communication with faculty in paleontology at a university in a neighboring town I learned that there were no women faculty members in their field and only 33% of the

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24 It was notable to observe how Reyna liked her mathematics professor in her freshman year and how he was a positive mediating artifact in her activity system at that time.
graduate students in recent years have been women (Dr. Smith, Dr. White and Dr. Wills, personal communication, March 24-25, 2005).

On the other hand, Reyna’s dislike of her biology courses represented a contradiction between the subject and the rules. This contradiction included Reyna’s need for women faculty as role models and the fact that there were none among the professors she had. A faculty member from the biology department supported the same fact: “I mean, [that women scientists do not prefer to stay in research] is not a bad thing [for them personally], it just creates problems that we do not have enough female role models in the universities to keep the women in the sciences” (Prof. Schwartz, Interview, October 20, 2004). This pointed to another contradiction between the rules and the object, since Reyna might have chosen to stay in biology straightforwardly had she had any women professors.

From the communities perspective, the uneven ratio of women and men faculty members in Reyna’s academic major community interfered with Reyna’s object, which was a strong contradiction. Reyna’s primary reaction to this situation was to switch her major to another one where she could have good role models. Then she made her object to be a paleontologist where she thought she would find women role models, and she did not have to change her biology major. So, her intention to go to a field where there were possibly more women implied that she did not consider staying in a field with predominantly men professors to become a role model herself. In other words, Reyna was more involved in internalizing the culture of the community of science in order to reach her outcome of having a job she would love than triggering externalization to make a difference, which would lead to transformation.

Being in the PWISEM was important for Reyna in terms of being academically successful in her courses. As a participant in this community she could study and go to classes with the other PWISEM women, and they supported one another through academic tutoring. In addition, listening to the speakers invited to the Program’s lectures helped her narrow down her options in biology in her first year. Thus, the PWISEM was a strong mediating artifact in Reyna’s activity system. Moreover, Reyna’s willingness to be a mentor for the new PWISEM students in her sophomore year was an indication of her active role in the division of labor within the PWISEM community and her strong ties
with the Program. It also meant that she really thought the Program, and especially mentoring, were beneficial.

Reyna also belonged to another social community, a sorority. It was very important for her to have a social life, but it was a challenge to balance her social life with school life, in other words to balance the division of labor between these different aspects. Reyna was more successful in that than in the last year and she was more sure of herself that she could do them all.

In her sophomore year, being an old-timer with respect to the new newcomers in the PWISEM, Reyna was more confident that she could succeed in her college life. However, the impersonal image of her major made her think about changing it. Reyna resolved the contradiction between herself (subject) and her object in a reasonable way and decided to stay in biology so that she can become a paleontologist. In the meantime, Reyna kept interacting with the PWISEM and, moreover, helping young women intending to major in biology. In other words, she still fulfilled her role within the PWISEM community as an old-timer.
CHAPTER 6

FINDINGS: CROSS-COMPARISONS OF THE CASES AND THE PRE-POSTTESTS

Introduction

This chapter is a joint one involving findings that emerged through both the qualitative and the quantitative paradigms informing the design of this research (discussed in Chapter 3). In the first part I approach the three cases of Carol, Lena and Reyna from a perspective highlighting the commonalities among them. These commonalities relate to the gendered identities of the participants, their perspectives on gender and its relation to SM&E, the contradictions they experienced as women students in these fields, and the role of the PWISEM in their participation in SM&E. The second part includes the results of my analyses of the posttest and their comparison to the results of the pretest. I discuss similarities and relationships with, or any differences of the PWISEM students from the comparison group (HGC) students regarding the variables of interest.

Cross-Comparisons of the Cases

Each of the three women in the individual findings depicted remarkable cases with worlds of their own, full of challenges, interactions, and contradictions, the fleshing out of which were possible primarily with the cultural-historical activity theory lens. Although some similarities existed, the women delineated a notable amount of diversity in their activity systems. Each of them had a different positionality (Barton, 1998) stemming from their different personal histories, perceptions of gender, science and of themselves as scientists, and different communities to which they belonged. With an awareness that strict concentration on comparing cases may compete with “learning about and from the particular case” (Stake, 2000, p. 444), in the section that follows I point out comparisons that might be made across the three cases of Carol, Lena and Reyna.
Feminine Identities

In contrast with feminine style, which I used in the previous chapter to refer to Carol’s womanliness relating to dressing and appearance, I suggest that feminine identity is a broader term. It refers to dressing and appearance and a woman’s disposition. Besides describing the traditional Western notions of feminine appearance such as high heels, pink fingernails and miniskirts, feminine identity concerns particular ways of interacting and habits of communication, or stereotypical behaviors associated with women.

Unlike Lena and Reyna, Carol was very explicit about her understanding of feminine identity and its relation to science. She consistently claimed being a “big girly girl” and “very feminine,” and that she would not change her “style” for anything or anyone. Considering that she was in engineering, a field traditionally considered as being heavy, dirty and masculine (Newton, 1986), it was apparent that she was on an extreme end. Also, given her explicit political awareness about her gender intersecting with science, which was in spite of belonging to a historically oppressed Hispanic culture, Carol seemed to have transcended her Hispanic identity into a more empowering one, Hispanic American ethnicity (Weedon, 2000). Weedon describes ethnicity as “the sense of belonging to a particular group” (p. 173) and not simply as the way a person looks.

On the contrary, Lena appeared to fit more the typical image of the field and that of a woman engineering student who would not be feminine in the same fashion that Carol worked to be. Most women in SM&E tended to appear “as plain and ‘neutral’ as possible –often by wearing a version of male student dress-” (Seymour, 1995, p. 454) to avoid notice and to be taken more seriously as scientists or engineers, and Lena seemed much more comfortable following this tradition.

When Carol claimed that she had an intense “feminine style,” she understood this “style” in terms of outer aspects of gendered performance, such as dressing and appearance. Each time she talked about her womanliness she focused on the outer manifestations of her feminine identity. Indeed, Carol dressed in a stereotypically womanly way. She usually wore make-up and dressed in miniskirt and sandals with at least some pink color in them. On the contrary, Lena was noticeably casual, with bluejeans and a t-shirt, and she did nothing special to appear feminine. Her hair was
always tied in the back, and I have never seen her wearing make-up. The vocabulary she employed when talking was different from Carol’s, too. Lena never used terms like “feminine” or “girly girl,” which often manifested in Carol’s language. In other words, as opposed to Carol, Lena was not explicitly concerned with a feminine identity. Instead, she was building potential to appear as a typical non-feminine woman engineer and not as a traditional Western woman.

Lena made contradicting comments about gender and science; at first, she appeared not to believe that there was any relation between them. Moreover, in our previous interview in her freshman year she had once stated that “gender did not exist for her” (Lena, Interview 1, November 12, 2003). However, when prompted more deeply in the follow-up interviews, Lena indicated that there was a masculine connotation all over the scientific field and that she mused whether there would be possible benefits of adding feminine perspectives to science. Her assertion was in parallel with those of feminist standpoint theorists who argue adding feminine approaches to science to maximize its objectivity and make it strong (Harding, 2001). Yet, Lena preferred to be more implicit about her identity as a woman in engineering, and about gender issues and their relation to science.

Like Lena, Reyna also was not very explicit about the gender problem in science, although she was the one who was most uncomfortable with the predominantly men faculty in her major. Reyna dressed in ways similar to Carol. For example, she often wore sleeveless tops in red or pink colors. She showed some signs of shyness which she mentioned in her self description; she was polite, and almost always smiled. Although these characteristics could be attributed to a stereotypical feminine identity, this identity being supposedly a common ground between Reyna and Carol manifested itself in different ways other than the dressing aspect. Carol claimed to be very feminine, but she enacted quite a different personality than Reyna’s. For example, Carol spoke forcefully as opposed to Reyna, whose voice was soft and not as assertive as Carol’s. This contrast once again points out Carol’s feminine style and Reyna’s intensely feminine identity.

It is vital to note that the participants’ perceptions of themselves as women in the SM&E fields and their conceptualizations of these fields in relation with gender, their gendered practices in everyday life, and my observations and interpretations of these
practices and perceptions, were in congruence with their Bem sex-role inventory (BSRI) (Bem, 1974) scores. As I mentioned in Chapter 3, the BSRI “was founded on a conception of the sex-typed person as someone who has internalized society’s sex-typed standards of desirable behavior for men and women…” (p. 157). The women completed the inventory as part of the pretest and the posttest at the beginning and end of their freshman year.

Carol, claiming a strong feminine identity but emphasizing its outer traditional manifestations common in Western societies, scored as androgynous on both the pre and posttests. According to Bem (1974) being androgynous means having simultaneously both masculine and feminine characteristics, and androgynous people are often very successful because they have multifaceted personalities. Androgynous people are not limited to, or restricted by “sex-typed” behaviors. They can be both assertive and yielding, both instrumental and expressive, as the particular situation requires (Bem, 1974). For example, when under pressure or facing obstacles androgynous women can be more assertive and independent than feminine women. Likewise, androgynous men can feel more comfortable taking care of babies, and are more able to show empathy and support other people than masculine men (Gershaw, 1995). Carol was a good example for an androgynous person because she wanted to accomplish much in her life, as I described in her case. Besides appearing feminine, she also stressed being ambitious, goal-oriented, and independent, which are stereotypically masculine characteristics. So, it was not surprising that Carol typified an androgynous individual.

Lena scored as near masculine on the pretest and as masculine (with highly significant difference) on the posttest. Given the strong paternal support that Lena received when she was growing up for getting involved in SM&E (i.e., encouraged to play with “boy toys”), this result is not surprising. As emphasized by Kahle and Lakes (1983), parental encouragement (or discouragement) and expectations are very influential in a child’s choice of extracurricular activities related with science. Also, concerning Lena’s close relationships with her men peers in the engineering major after she enrolled in college, this result/shift is not unexpected. Lena’s somewhat implicit approach to the link between gender and science, her casual appearance, and personality characteristics
such as being individualistic that are stereotypically masculine, also supported her standpoint to appear masculine.

Reyna was categorized as near feminine on the pretest and as feminine on the posttest. Her major selection may be an indication of her preference to enter a field perceived as more feminine (Farenga & Joyce, 1999; Jones et al., 2000; Vockell & Lobonc, 1981; Weinburgh, 1995) and where there were a lot of women. Also, she did not want to be a minority in her discipline, and biology was a suitable choice because it has recently attracted more women than men at undergraduate level. Reyna’s explanation for the high number of women was remarkable. According to her, since there was not much mathematics involved in biology there were a lot of women in this field, implying her perception of the low confidence of girls to pursue mathematics-related careers (AAUW, 1992). Having relationships with the women, who were more numerous than men in her major, might have reinforced her already feminine identity over time. Other than that, as revealed in her self description and our conversations, Reyna had characteristics such as being shy, soft spoken, and cheerful, which are considered stereotypical feminine characteristics (Bem, 1974). She was also so keen on personal relationships and on having good women role models among her professors that she almost switched out of biology; according to Reyna her major was lacking these. Reyna’s appearance and dressing being similar to Carol’s also supported her feminine identity.

Gender and SM&E

All three women were aware of the men dominance in the SM&E fields. However, they conceptualized it as dominance in terms of numbers, and not in terms of gendered components involved in scientific tools and practice, as opposed to feminist critiques of science arguing subtle epistemological marginalization of women besides overt discrimination (Nichols et al., 1998). The only one who mentioned the existence of “masculine connotation in the science field” (Lena, Interview 2, October 28, 2004) was Lena; however, she did not make a consistent argument and seemed to contradict herself at the same time by arguing the absence of a predominantly masculine perspective in

25 My assumption here was that if not all, the majority of the women pursuing biology major were as feminine as Reyna given the feminine “label” of the field.
science or gendered characteristics a scientist would have. All three perceived “change” in the SM&E fields as higher participation by women, like liberal feminists such as Mary Wollstonecraft who insisted on equal education for women with men (Weedon, 2000). Although arguing “adding more femininity/personality to the field” (Carol, Interviews 1, 2, November 14, 2003, October 28, 2004) Carol did not think it in terms of altering the traditional gendered language and practices. On the other hand, Lena saw the potential benefits of adding feminine perspectives since once she mentioned that women might be better than men at “looking at problems from different angles” (Lena, Interview 2, October 28, 2004), but this idea was no commonly offered by her.

Both Reyna and Lena emphasized the importance of having women role models in the SM&E fields, which was related with a psychoanalytic feminist perspective suggesting that women might feel closer to women than to men because their primary caretakers are traditionally women (Rosser, 1997). In other words, women’s relationships among themselves might be more affective than their relationships with men because of the stronger bond between mother and daughter than that between mother and son in the early stages of life. Since women could relate better to other women than to men it was important that young women and girls had women role models in SM&E. For this reason, Wygoda (1993) stresses the importance of discussing women scientists in high school classrooms in order to provide young women students with the role models they need.

Regarding their standpoint in solving the gender problem in the science fields, to more or less a degree, all three women had a liberal feminist approach. They considered that if women were not discriminated based on their sex, more and more women would participate in these fields reaching equality with men (Rosser, 1997; Scantlebury, 2002; Weedon, 2000). Women’s participation was also important in terms of becoming role models, the recognition of which I discussed above. Concerning their approach, these three young women were more likely to internalize the culture of SM&E (Lederman, 2003) than to trigger externalization to challenge and transform the status quo of scientific practice. Contrasting Lena who fit better with the “less feminine” image of women in engineering and science (Seymour, 1995), Carol and Reyna tended to aim for careers/positions more compatible with their feminine styles/identities, but less powerful and more marginal (Eisenhart & Finkel, 1998).
Unlike Lena, Carol and Reyna made judgments about their future studies and careers based on their perceptions and expectations. These perceptions and expectations were largely based on the men-dominated nature of the SM&E fields. For example, Carol was very determined to keep her “feminine style” even if that would cost her a job. She was also concerned about possibly not being able to be (in her estimation) an “actual” scientist in the field and at the same time have family and be a mother. Cronin and Roger (1999) revealed that such a concern was one among many of the struggles women experienced within SM&E. On the other hand, Reyna had a men-dominated group of professors through which to understand what it means to be a biologist, so she rejected that portrait of a scientist for herself. Despite their concerns about their future SM&E careers, both Reyna and Carol were very successful in meeting the academic rigor of their fields (both having a high GPA). In contrast, Lena had some difficulties in her core classes, which made her think seriously about dropping out of the major. However, she also had a more realistic image of her field through her internship, which was the leading factor she did not give up. The internship provided Lena with access to more authentic language and cultural practices of SM&E, which were meaningful positive experiences allowing her to continue to pursue her field. As she emphasized in her self-description, Lena enjoyed witnessing “something being developed from nothing” (Lena, electronic mail, March 31, 2005) Although in some cases such realistic images function as encouraging factors as it was for Lena, for many others they became reasons to make decisions about not pursuing their intended careers (Seymour, Hunter, Laursen, & Deantoni, 2004). Nevertheless, in both cases they represented real life applications of the university SM&E education.

Both Carol and Reyna focused on personal relationships not being the norm in their fields. Carol thought it was because the professors were overloaded and they did not have time to spend with their students outside of class. Reyna’s problem was a bit different; since all of her professors were men, and as she perceived them, “distant,” she felt hesitant to approach them and seek assistance. Carol’s, and especially Reyna’s frustration regarding the lack of or insufficient personal pedagogical relationships support Seymour’s (1995) argument that “more women than men arrived in college with the expectation of establishing a personal relationship with faculty” (p. 464), and in both
cases this need was left unfulfilled. On the other hand, Lena also mentioned experiencing difficulties in approaching some of her professors, but she did not seem to be concerned about that as much as Reyna and Carol were.

**Contradictions**

Carol, Lena and Reyna experienced various contradictions within their activity systems in SM&E. The diverse nature of their activity systems once again confirmed the unique positionalities they had even in the same contexts. Here, I summarize these contradictions (shown in Figure 6-1) and then elaborate on the one that I identified as being common for the three women.

![Figure 6-1. Summary of contradictions.](image)

In the figure I inserted the name of the participant where she experienced a contradiction. Some of the activity system components or the spaces between these
components included only one name, meaning that this contradiction was experienced only by one of the three women. At some places there were two names, pointing to a common contradiction for the two of the women. Only the space between rules and object included all the three names and that was where the three participants had a common contradiction.

For Carol, the contradiction between subject and rules involved her strong sense of “feminine style” being in conflict with the unstated rules of her field to appear masculine. For Reyna, this contradiction pointed to her need for women faculty as role models and the fact that there were none among the professors she had. It also included the fact that she did not enjoy her biology courses.

Carol and Reyna had another contradiction in common, as well. It was between the communities and their objects. The uneven ratio of women and men faculty members in Reyna’s academic major community interfered with her object of becoming a biologist. She was uncomfortable with the predominantly men faculty in her major and considered switching. For Carol, this contradiction was caused by the insufficient mentoring the engineering faculty at that university provided to their students. This situation hindered Carol’s goals to some extent.

Both Carol and Lena experienced a contradiction within their academic major communities. Carol’s experience was related with the insufficient mentoring that I mentioned above. Although Dr. Ross, a faculty member in the College of Engineering, thought that efficient mentoring was taking place, Carol was not satisfied with it. In other words, what was sufficient for the faculty might not have been enough for the students at that university. On the other hand, Lena discovered that the women in her major felt a need to behave in certain ways because they were in engineering. This situation represented inconsistent and unequal expectations from the members of the community of civil engineering.

The common contradiction between division of labor and object for Carol and Lena was also common in nature. Both women experienced insufficient mentoring, which meant that the professors in their academic major communities were not fulfilling their roles as advisors.
Contrasting the other two women, there was a major contradiction between the object and the outcome in Carol’s activity system. Although Carol insisted that she would “add more personality to the [engineering] field” (Carol, Interviews 1, 2, November 14, 2003, October 28, 2004), she also mentioned that she would “turn down” a job where she is required to change her style. In spite of her determination to add more personality to the field, Carol’s tendency was towards getting a position in engineering which would allow her to be herself, and to have more flexible work hours and family time.

Lena experienced a number of contradictions different from the other two women’s. Her competing arguments about the relationship of science and gender signaled contradictions within her own thinking, the subject. Another aspect of this contradiction within the subject involved the fact that she felt less confident to pursue engineering in her sophomore year because of her struggle with core courses like physics and calculus. These courses as mediating artifacts also formed a contradiction with Lena’s object.

The contradictions within the division of labor component and between the communities and division of labor in Lena’s activity system were related with the poor relations among the women in her major. Unlike Carol and Reyna, Lena observed and experienced minimal or no relationships among her women peers in the major. She had more men friends than women, and she stated that it was easier to approach the men in her academic community than the women. The poor relations among the women in her major represented a contradiction in the division of labor within the academic major community, which would otherwise be another academic support for Lena and her women peers.

Such an attitude among women in the SM&E fields signaled lack of a feminist identity or a strong identity as a woman which would motivate women in these fields toward collective action (Liss et al., 2004). As Seymour (1995) suggests, the young women in engineering might have adopted the “invisibility” metaphor not to draw attention to their gender, by not even bonding with their women peers. Yet, a sense of solidarity and collegiality would enhance the women’s success in fields that are traditionally considered to be masculine. For this reason, initiatives for encouraging more women into the SM&E fields, including the PWISEM that is central to this research, are
primarily working toward enhancing the sense of unity among them for academic success.

An important and the only commonality among the three women was their experience of a contradiction between the *rules* and the *object* of their activity systems. All three wanted to become successful scientists in their fields; however, each of the women faced obstacles stemming from the men-dominated nature and the masculine culture of these fields. As I mentioned before, they found the SM&E fields impersonal; they could not have strong relationships with their professors. Another challenge these young women met was the “hardness,” or the difficulty of the courses in their majors, part of the culture of SM&E.

Reyna’s basis for intending to drop out of her major was that all of her professors in biology were men and poor role models. For Lena, the situation was different but the intention to switch was the same. Her struggle with her core courses and failing one of them became her reasons to drop out. Both Reyna and Lena sought outside aid, which they primarily got from their families and friends. On the other hand, Carol was the one who was affected by these negative SM&E experiences the least. She never thought of dropping her major. The fact that Carol scored androgynous according to the BSRI and her approach to meet challenges support Bem’s (1974) assertion that individuals endorsing both feminine and masculine characteristics are more successful and define “a more human standard of psychological health” (p. 162) than those who are either feminine or masculine.

Although each of the three women experienced a contradiction between the rules and the object of their activity systems, Carol and Reyna’s common struggle was directly related with the gendered nature of the SM&E fields, while Lena’s problem was her low performance in the core courses. Both Carol and Reyna appeared feminine, and their feminine style/identity was in odds with the unstated rules of their fields to appear masculine. Moreover, it was crucial for Reyna to have women role models as biologists to whom she would relate better. Given their feminine style/identity, both Reyna and Carol as subjects contradicted the rules of the community of science. On the other hand, since Lena did not claim having feminine aspects—as also supported by her BSRI score-
she appeared comfortable in her major. Instead, she was quickly losing confidence to pursue civil engineering, which led to a contradiction within herself (subject).

The PWISEM

Each of the three women found their participation in the PWISEM as valuable. They expressed that the Program was beneficial primarily in two ways: First of all, it was crucial for them to live together with other women in the SM&E majors in their first year. It was comforting to know that there were others who were going through the same academic challenges, and it was easier to adjust to college life. Living together as a community made it easier to stay in their majors and keep themselves motivated. The three women emphasized this first point more during our interviews last year, when they were freshmen (discussion available in Chapter 4). Secondly, being in the Program was helpful in terms of obtaining academic support. This was possible through interacting with peers in the Program, guest speakers (scientists) and staff (i.e., with the Director, Dr. Jones), and through paid tutors.

Lena benefited from the Program mainly in the second way. She talked about the academic support she got through her peers as they could “sit in the lobby and all do homework together” (Lena, Interview 2, October 28, 2004). The fact that her struggle with her courses appeared in the sophomore year when she was no longer living in the residence hall with the other PWISEM women can be argued to be of the impact of the Program on Lena’s academic achievement in her freshman year.

Besides emphasizing the academic support, Carol and Reyna implied that participating in the Program was very helpful in terms of adjusting to college and to being a SM&E student. Both women talked about the positive effect of having proximity with other women in SM&E in their freshman year. That helped them to adjust easier to college as newcomers. Having contact with upperclassmen peers, or old-timers, was also an important source of help (Seymour, 1995). Although Carol mentioned that the PWISEM women were not as outgoing as she was and there was hardly someone from the Program to join her in social activities, this situation did not seem to hinder her from embracing the benefits of the Program.
Both Carol and Reyna highlighted the mentoring experience they had in the PWISEM. Carol still communicated with Dr. Jones in her sophomore year for academic advising, and Reyna volunteered to be a mentor herself for the new PWISEM participants. Reyna and Carol’s emphases about their positive experiences in the Program were similar to each other but different from Lena’s. This contrast supported their having more feminine characteristics than Lena. The two women’s difference was in the sense that Reyna and Carol seemed to value personal relationships (Belenky et al., 1986; Gilligan, 1982; Seymour, 1995) with women colleagues (in this case, with women in SM&E) more than Lena did.

None of the women talked about the benefits of the PWISEM as encouraging solidarity/collegiality among the participating women in terms of gender issues in SM&E. They did not refer to the Program as being helpful in approaching/solving conflicts in their fields in terms of gender. Although the Program’s approach involved a radical feminist perspective because its context was reminiscent of a “women-only environment” (Rosser, 1997), issues such as challenging the masculine structure of science were out of its scope. The women’s experiences within the Program are in congruence with its primarily liberal feminist approach, which argues the equality of women to men without challenging the status quo of the positivistic approach to scientific research (Rosser, 1997; Scantlebury, 2002; Weedon, 2000). The PWISEM provided extensive academic support through interactions with peers, guest speakers (scientists) and staff (i.e., with the Director, Dr. Jones) so that the young women “learn about and embark upon” (Cronin & Roger, 1999, p. 650) careers in SM&E. The three women recognized the Program’s academic support and seemed to conform to its approach of changing the SM&E fields by ensuring higher participation by women.

The Posttest and its Comparison to the Pretest

In this section, I return to the discussion of the results revealed through the survey instrument of this research. This discussion temporarily shifts the focus of the research to more generic patterns. As compared to the section in the Pilot Study (Chapter 4) concerning the pretest results, this part includes the results of my analyses of the posttest and their comparison to the pretest. I discuss similarities and relationships with, or any
differences of the PWISEM students from the comparison group (HGC) students regarding the variables of interest. I make these comparisons for both the beginning and the end of the 2003-2004 academic year. The contrasts between the groups of PWISEM and non-PWISEM students help to better understand the role of the PWISEM in the students’ participation in SM&E.

I presented the posttest results, and their comparison to the pretest results by using one-way ANOVA (as I discussed in the Methods of Data Analysis section of Chapter 3). I gave the posttest to the PWISEM and HGC student groups at the end of the academic year 2003-2004. The response rate for the PWISEM students was 94.3% (33 out of 35 students completed the survey). The HGC students had a response rate of 60.3% (38 out of the 63 students who had completed the pretest completed the posttest). To increase the response rate of the HGC students I used an electronic version of the survey for those who did not return the hard copy version or were absent in class during the distribution.

As I discussed before (in Chapters 3 and 4), the independent variable in my research was academic program (PWISEM versus HGC)\(^{26}\), and my dependent variables of interest were: (1) interest, (2) confidence, and (3) determination in pursuing one of the SM&E majors (CIRP, 2000), (4) views on science and scientists (NORC, 2004), (5) interest in and (6) understanding of science and technology (NORC, 2004), and (7) psychological sex-role stereotyping/androgyny as measured by the Bem Sex Role Inventory (BSRI) (Bem, 1974). Besides discussing the results regarding these dependent variables I also presented the results of the group comparisons with respect to the students’ cumulative GPAs and intended/declared majors both in the beginning and at the end of the academic year. The scores of these two dependent variables served as external criteria to obtain criterion-related validity (Babbie, 1998) for the first three dependent variables mentioned above.

\(^{26}\) In my analyses, I broke down the two groups (PWISEM and HGC) into three. These three groups were the PWISEM group, the female HGC students group, and the male HGC students group. My purpose here was to contrast the two female groups with the male group (as discussed in Chapter 3).
Interest

Like in the pretest, in terms of their interest in pursuing one of the SM&E majors, the three groups embodied no significant difference (Table 6-1). In other words, all of the students expressed almost the same level of interest, and the group means ranged from 4.36 to 3.85 (5.00 being the highest and 1.00 being the lowest interest score on the scale, see item 12 on the posttest in Appendix G). The mean score of 4.36 belonged to the PWISEM student group and the mean score of 3.85 belonged to the HGC men students group.

Confidence

When compared in terms of their confidence in pursuing one of the SM&E majors, the students did not differ significantly (Table 6-1), as was the case with the confidence in the pretest. Like the interest variable, the confidence variable revealed that all of the students expressed similar level of confidence in being in these majors.

Table 6-1. Comparison of the student groups in terms of interest and confidence

<table>
<thead>
<tr>
<th>Items</th>
<th>PWISEM Students (N=33)</th>
<th>HGC Women Students (N=18)</th>
<th>HGC Men Students (N=20)</th>
<th>One-way ANOVA p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 12 (Interest)</td>
<td>4.36 0.96</td>
<td>4.17 1.30</td>
<td>3.85 1.50</td>
<td>0.336</td>
</tr>
<tr>
<td>Item 13 (Confidence)</td>
<td>3.94 0.91</td>
<td>4.11 0.83</td>
<td>4.00 0.65</td>
<td>0.776</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Posttest, 2004

* Confidence interval: 95%
The mean scores for the groups ranged from 3.94 to 4.11 (again, 5.00 being the highest confidence score in the range, and 1.00 being the lowest, see item 13 on the posttest in Appendix G). In fact, the PWISEM students’ confidence mean score was exactly the same, 3.94, in the pretest. Considering the means in the posttest, the PWISEM students scored the lowest (3.94) and the HGC women students scored the highest (4.11) on the confidence scale, but there was no statistical difference.

**Determination in pursuing one of the SM&E majors**

According to student responses to Item 14 (see the posttest in Appendix G) and the results of crosstabulation and Chi-square test, 88.9% of the HGC women students were “certain of their academic major” as compared with 57.6% PWISEM students and 50.0% HGC men students (Table 6-2).

<table>
<thead>
<tr>
<th>Determination (Item 14)</th>
<th>PWISEM Students</th>
<th>HGC Women Students</th>
<th>HGC Men Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>You are certain of your academic major.</td>
<td>57.6%</td>
<td>88.9%</td>
<td>50.0%</td>
</tr>
<tr>
<td>You have narrowed down your academic major to several possibilities.</td>
<td>36.4</td>
<td>0</td>
<td>45.0</td>
</tr>
<tr>
<td>You need assistance in deciding.</td>
<td>6.1</td>
<td>5.6</td>
<td>5.0</td>
</tr>
<tr>
<td>You do not know at the moment, but you will decide on your own.</td>
<td>0</td>
<td>5.6</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100.0% (33)</td>
<td>100.0% (18)</td>
<td>100.0% (20)</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Posttest, 2004
Forty-five percent of the HGC men students and 36.4% of the PWISEM students “have narrowed down their academic major to several possibilities.” There were no students from the HGC women students group in this category. In contrast with the students’ responses to this item in the pretest, there was a significant relationship among the groups in the posttest, χ²(6, N=71)=13.004, p=0.043. More HGC women students were certain of their academic major than the other two student groups such that there were even not any HGC women who have narrowed down their possibilities.

When Table 6-2 is examined closely, the bulk of the HGC women students (88.9%) were in the first category of the item while the other two groups were distributed almost evenly between the first and the second categories. Considering the non-significant result in the pretest, it is possible to argue that over one academic year the HGC women students became the most determined group among the three in terms of their major.

**Views on Science and Scientists**

Regarding items 2 through 11 (see posttest in Appendix G) that included the NOS items, in general, the student groups expressed similar comments. The only statistically significant differences existed in terms of items 3, 4 and 7 (Table 6-3) 27.

Concerning Item 2, “it is not important for me to know about science in my daily life,” all of the students disagreed/strongly disagreed supporting the link between everyday and scientific knowledge (Ash, 2004). The groups had disagreed/strongly disagreed with the statement in the pretest, as well. Such a population of students has great potential in harmonizing with Roth and Lee’s (2004) call for teaching (and learning) science as contribution to the solution of everyday life problems instead of as one attempting to make connections to bridge an artificial divide of in- and after-school experiences.

The analysis of variance revealed that the PWISEM group and the HGC women group differed significantly in their responses to Item 3, “a scientist usually works alone,” F(2, 68)=3.26, p=0.044, in the sense that the latter disagreed more strongly with the

27 The scale for these items was as following: 1-Strongly agree, 2-Agree, 3-Disagree, 4-Strongly disagree.
statement. Post hoc analyses using the Tukey HSD criterion for significance indicated
that the HGC women students group disagreed more strongly \((M=3.56, SD=0.51)\) than
the PWISEM group \((M=3.15, SD=0.62)\). In the pretest, all the three groups had disagreed
with the item but there was no significant relationship. The students’ disagreement with
the item indicated that they recognized the collective nature of scientific work “–in sharp
contrast to a popular stereotype of science as a lonely, isolated search for the truth…. Scientific research cannot be done without drawing on the work of others or collaborating
with others” (NAS, 1995, p. 3).

Regarding Item 4, “scientific researchers are dedicated people who work for the
good of humanity,” there was a statistical difference among the groups, \(F(2, 68)=3.66,
p=0.031\). Post hoc analyses using the Tukey HSD criterion for significance revealed that
the PWISEM group agreed more strongly \((M=1.67, SD=0.48)\) than the HGC womens
group \((M=2.06, SD=0.64)\). In the pretest, all the three groups had agreed with the item
but there was no significant relationship. To agree with this item was in opposition of a
traditional image of science as destructive, dangerous, and war-related held by many girls
and boys (Jones, 1990, as cited in Jones et al., 2000; Jones et al., 2000).

All three groups strongly agreed/agreed that “scientists are helping to solve
challenging problems” (Item 5) both in the pretest and posttest. Regarding Item 6,
“scientists are apt to be odd and peculiar people,” the students had similar responses in
the posttest and tended to disagree. However, in the pretest, the HGC men student group
had differed from the two women groups in the sense that the men students had a
tendency to agree with the statement. Namely, the three groups converged with respect to
their image of scientists after one academic year. This image was one as more integrated
with the ordinary society (scientists as normal people).

The PWISEM students agreed significantly more strongly \((M=1.79, SD=0.55)\)
with Item 7 being “most scientists want to work on things that will make life better for
the average person” than the HGC women students \((M=2.17, SD=0.51)\), \(F(2, 68)=3.32,
p=0.042\). In the pretest, all of the students had agreed with the item with no significant
difference.

Concerning Item 8, “scientists are not likely to be very religious people,” the three
groups were alike in their disagreement to the statement in the posttest. However, in the
pretest, there was a significant difference between the PWISEM students and the HGC men students in the sense that the PWISEM students had more strongly disagreed. Considering the posttest results, the students seemed to collectively have adopted a more integrated image of science with religion.

### Table 6-3. Comparison of the student groups in terms of views on science and scientists

<table>
<thead>
<tr>
<th>Items</th>
<th>PWISEM Students (N=33)</th>
<th>HGC Women Students (N=18)</th>
<th>HGC Men Students (N=20)</th>
<th>One-way ANOVA P value *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Item 2</td>
<td>3.42</td>
<td>0.71</td>
<td>3.50</td>
<td>0.62</td>
</tr>
<tr>
<td>Item 3</td>
<td>3.15</td>
<td>0.62</td>
<td>3.56</td>
<td>0.51</td>
</tr>
<tr>
<td>Item 4</td>
<td>1.67</td>
<td>0.48</td>
<td>2.06</td>
<td>0.64</td>
</tr>
<tr>
<td>Item 5</td>
<td>1.45</td>
<td>0.51</td>
<td>1.72</td>
<td>0.75</td>
</tr>
<tr>
<td>Item 6</td>
<td>2.79</td>
<td>0.78</td>
<td>2.50</td>
<td>0.71</td>
</tr>
<tr>
<td>Item 7</td>
<td>1.79</td>
<td>0.55</td>
<td>2.17</td>
<td>0.51</td>
</tr>
<tr>
<td>Item 8</td>
<td>3.09</td>
<td>0.68</td>
<td>2.72</td>
<td>0.67</td>
</tr>
<tr>
<td>Item 9</td>
<td>3.18</td>
<td>0.77</td>
<td>2.94</td>
<td>0.54</td>
</tr>
<tr>
<td>Item 10</td>
<td>3.36</td>
<td>0.65</td>
<td>3.56</td>
<td>0.51</td>
</tr>
<tr>
<td>Item 11</td>
<td>2.09</td>
<td>0.84</td>
<td>1.94</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Posttest, 2004

* Confidence interval: 95%

† Significant mean differences at the 0.05 level

There was no statistically significant difference in the groups’ responses to Item 9, “scientists have few other interests but their work.” All three groups disagreed with the statement, as they did in the pretest. Their disagreement is closely related with rejecting the “odd” image of scientists (Item 6).

The students also disagreed/strongly disagreed with Item 10, “something that is proven by using the scientific method is a fact, and therefore no longer subject to change.” They agreed with Item 11, “scientists use their creativity and imagination during and after data collection.” The students’ responses regarding these two NOS items were
the same in the pretest. These results implied that the students had “more informed views” of the tentativeness aspect of NOS and the creative and imaginative aspect of NOS (Lederman et al., 2002) and that their views did not change over time.

**Interest in and Understanding of Science and Technology**

**Interest**

All of the three groups were alike in their responses to Items 15 and 16 about interest in “issues about new scientific discoveries” and “issues about the use of new inventions and technologies,” relatively. They were very/moderately interested in these issues without a significant difference (Table 6-4)\(^{28}\). In contrast, according to the pretest, the HGC men students were significantly more likely to be very interested in “the use of new inventions and technologies” than the HGC women group.

Regarding Item 17 about interest in “issues about environmental pollution” there was statistically significant difference among the groups \(F(2, 68)=3.56, p=0.034\). Post hoc analyses using the Tukey HSD criterion for significance revealed that the HGC women students were more likely to be very interested in these issues (\(M=1.71, SD=0.58\)) than the PWISEM students group was (\(M=2.12, SD=0.49\)). In the pretest, there was no significant difference regarding this item.

Concerning “issues about the use of nuclear energy to generate electricity” (Item 18) the PWISEM students were the least interested group (\(M=2.45, SD=0.56\)) than the other two groups (\(M=1.94, SD=0.64\), (\(M=1.80, SD=0.70\)), with significant difference, \(F(2, 68)=8.09, p=0.001\). In the pretest, the groups did not differ significantly regarding this item.

**Understanding**

Although their interest in “issues about new scientific discoveries” (Item 19) was similar, the groups showed significant difference in being informed about the same issues \(F(2, 68)=3.81, p=0.027\). Post hoc analyses using the Tukey HSD criterion for

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\(^{28}\) The scale for items 15-18 was as following: 1-Very interested, 2-Moderately interested, 3-Not at all interested, and for items 19-24 it was as following: 1-Very well informed, 2-Moderately well informed, 3-Poorly informed.
significance revealed that the HGC men students were more likely to be very well informed (\(M=1.85, SD=0.37\)) than the HGC women students (\(M=2.22, SD=0.43\)). This might point to research findings that boys and men tend to appear more confident in SM&E than girls and women although their achievement levels are the same. Relevantly, such a result may be supportive of the argument that men respond to such self-efficacy related instruments more congratulatory of themselves as opposed to women who are more modest (Schunk & Pajares, 2002). In the pretest, there was no significant difference with respect to this item. The students’ experiences in the university SM&E culture might have highlighted gender differences with respect to self-efficacy in these fields.

Table 6-4. *Comparison of the student groups in terms of their interest in and understanding of science and technology*

<table>
<thead>
<tr>
<th>Items</th>
<th>PWISEM Students (N=35)</th>
<th>HGC Women Students (N=29)</th>
<th>HGC Men Students (N=34)</th>
<th>One-way ANOVA P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Item 15</td>
<td>1.64</td>
<td>0.55</td>
<td>1.61</td>
<td>0.50</td>
</tr>
<tr>
<td>Item 16</td>
<td>1.61</td>
<td>0.56</td>
<td>1.56</td>
<td>0.51</td>
</tr>
<tr>
<td>Item 17</td>
<td>2.12</td>
<td>0.49</td>
<td>1.72</td>
<td>0.58</td>
</tr>
<tr>
<td>Item 18</td>
<td>2.45</td>
<td>0.56</td>
<td>1.94</td>
<td>0.64</td>
</tr>
<tr>
<td>Item 19</td>
<td>2.09</td>
<td>0.46</td>
<td>2.22</td>
<td>0.43</td>
</tr>
<tr>
<td>Item 20</td>
<td>2.15</td>
<td>0.57</td>
<td>2.33</td>
<td>0.49</td>
</tr>
<tr>
<td>Item 21</td>
<td>2.09</td>
<td>0.77</td>
<td>2.11</td>
<td>0.58</td>
</tr>
<tr>
<td>Item 22</td>
<td>2.39</td>
<td>0.75</td>
<td>2.44</td>
<td>0.51</td>
</tr>
<tr>
<td>Item 23</td>
<td>2.55</td>
<td>0.56</td>
<td>2.22</td>
<td>0.73</td>
</tr>
<tr>
<td>Item 24</td>
<td>2.85</td>
<td>0.44</td>
<td>2.56</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Posttest, 2004

* Confidence interval: 95%

† Significant mean differences at the 0.05 level
All of the students were similar in their responses that they were moderately well informed about “issues about the use of new inventions and technologies” (Item 20), “issues about new medical discoveries” (Item 21), “issues about space exploration” (Item 22), and “issues about environmental pollution” (Item 23), like they were in the pretest. However, the student groups differed significantly in their responses to Item 24 about being informed in “issues about the use of nuclear energy to generate electricity,” $F(2, 68)=6.26$, $p=0.003$. The PWISEM students were poorly informed regarding these issues ($M=2.85$, $SD=0.44$) as opposed to the HGC men students who were moderately well informed ($M=2.30$, $SD=0.73$). In the pretest, the groups did not differ significantly regarding this item. Interestingly, the PWISEM students scored consistently less interested and poorly informed about issues related with nuclear energy and electricity as compared with the other two groups in the posttest.

*Psychological Sex-Role Stereotyping/Androgyny - Bem Sex Role Inventory (BSRI)*

According to the results of the students’ responses to the BSRI in both the pretest and the posttest, I constructed a crosstabulation table (Table 6-5), which showed the percentage of the students in each group who categorized as near feminine, feminine, near masculine, masculine, or androgynous.

According to the crosstabulation and Chi-square test the relationship between academic program and BSRI categories was not statistically significant, as opposed to the pretest according to which there was a significant relationship, $\chi^2(8, N=98)=21.527$, $p=0.006$. The most androgynous group was the HGC men students group in the pretest, which was not the case in the posttest. Since the beginning of the academic year when the HGC men were mainly categorized as androgynous, near masculine and masculine, 15% of the students from this group categorized as near feminine in the posttest (as compared to zero students in this category in the beginning of the year). Also, more students from the HGC men students group categorized as masculine (30%). It seems like many men from the androgynous category switched to the near feminine and masculine categories after one academic year. Regarding the women student groups, the percentage of the PWISEM students categorizing as masculine increased while the percentage of near
masculine students decreased. Also, more women were categorized as near feminine since the beginning of the academic year in the HGC women students group.

Table 6-5. Academic program and BSRI scores crosstabulation

<table>
<thead>
<tr>
<th>BSRI Scores*</th>
<th>PWISEM Students</th>
<th>HGC Women Students</th>
<th>HGC Men Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Feminine (t ≥ 2.025)</td>
<td>14.3%</td>
<td>18.8%</td>
<td>17.2%</td>
</tr>
<tr>
<td>Near Feminine (1 &lt; t &lt; 2.025)</td>
<td>28.6</td>
<td>21.9</td>
<td>6.9</td>
</tr>
<tr>
<td>Androgynous (-1 ≤ t ≤ +1)</td>
<td>37.1</td>
<td>40.6</td>
<td>48.3</td>
</tr>
<tr>
<td>Near Masculine (-2.025 &lt; t &lt; -1)</td>
<td>17.1</td>
<td>9.4</td>
<td>13.8</td>
</tr>
<tr>
<td>Masculine (t ≤ -2.025)</td>
<td>2.9</td>
<td>9.4</td>
<td>13.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0% (35)</td>
<td>100.0% (32)</td>
<td>100.0% (29)</td>
</tr>
</tbody>
</table>

Source: PWISEM / HGC Pretest, 2003 and Posttest, 2004

* I took the category cutoff points for the \( t \) value from Bem’s (1974) study involving undergraduate students from two different universities.

GPAs and Intended/Declared Majors

I obtained the students’ cumulative GPA records for the academic year 2003-2004 and their declared majors as of the first semester of the academic year 2004-2005 from the Office of Admissions and Records of the University. These records were official documents the purpose of which was to serve as supplemental information (Bogdan & Biklen, 1998) in my research (as I discussed in Chapter 3).

The student groups did not differ significantly in terms of their cumulative GPAs (Table 6-6) at the end of their freshman year. All of the groups had GPA means above 3.00, which indicates their academic success. The PWISEM students had a GPA mean
score of 3.31, the HGC women students’ GPA mean score was 3.51, and the HGC men students had a GPA mean score of 3.40.

According to the results of crosstabulation and Chi-square test that I performed for the students’ intended/declared majors in the beginning of their freshman year, there is no statistically significant relationship among the groups (Table 6-7). In the beginning of the academic year 2003-2004, the majority of the students from all of the three groups intended to pursue a SM&E major (93.5% of the PWISEM students, 76.9% of the HGC women students, and 86.2% of the HGC men students). Noticeably, there were no students from both the PWISEM and the HGC men students group that wanted a non-SM&E major. Eleven and half percent of the HGC women students were in this category.

Table 6-6. Comparison of the student groups in terms of GPA

<table>
<thead>
<tr>
<th></th>
<th>PWISEM Students (N=32)</th>
<th>HGC Women Students (N=26)</th>
<th>HGC Men Students (N=30)</th>
<th>One-way ANOVA p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>GPA</td>
<td>3.31</td>
<td>0.58</td>
<td>3.51</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Source: University Records, Fall 2004

* Confidence interval: 95%

However, at the end of the same academic year, especially from the HGC women students group, there were more students deciding for a non-SM&E major (Table 6-8). Moreover, according to the results of the crosstabulation and Chi-square test the relationship between the groups and their declared majors was significant, $\chi^2(4, N=86)=9.618, p=0.047$. When examined closely, a considerable number of HGC women students (30.8%) and also HGC men students (13.8%) declared a non-SM&E major. Also, compared with the beginning of the academic year, there were fewer students in the
undecided category from both the HGC women and HGC men groups. Namely, more students from these groups decided on the major they wanted to pursue, but most of these students decided not to have a SM&E major. In other words, after one year significantly more PWISEM students remained in the SM&E fields than students in either of these other groups.

Table 6-7. Academic program and major type in the beginning of the academic year crosstabulation

<table>
<thead>
<tr>
<th>Major Type</th>
<th>PWISEM Students</th>
<th>HGC Women Students</th>
<th>HGC Men Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
</tr>
<tr>
<td>SM&amp;E</td>
<td>93.5%</td>
<td>76.9%</td>
<td>86.2%</td>
</tr>
<tr>
<td>Non-SM&amp;E</td>
<td>0</td>
<td>11.5</td>
<td>0</td>
</tr>
<tr>
<td>Undecided</td>
<td>6.5</td>
<td>11.5</td>
<td>13.8</td>
</tr>
</tbody>
</table>

TOTAL 100.0% (31) 100.0% (26) 100.0% (29)

Source: PWISEM / HGC Pretest, 2003

Table 6-8. Academic program and major type at the end of the academic year crosstabulation

<table>
<thead>
<tr>
<th>Major Type</th>
<th>PWISEM Students</th>
<th>HGC Women Students</th>
<th>HGC Men Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
<td>Percent of Total Cases</td>
</tr>
<tr>
<td>SM&amp;E</td>
<td>90.3%</td>
<td>69.2%</td>
<td>82.8%</td>
</tr>
<tr>
<td>Non-SM&amp;E</td>
<td>3.2</td>
<td>30.8</td>
<td>13.8</td>
</tr>
<tr>
<td>Undecided</td>
<td>6.5</td>
<td>0</td>
<td>3.4</td>
</tr>
</tbody>
</table>

TOTAL 100.0% (31) 100.0% (26) 100.0% (29)

Source: University Records, Fall 2004
These results are competing with the results about the students’ interest and confidence in pursuing SM&E majors. Although there was no significant difference among the groups in terms of interest and confidence, there were differences regarding decisions for majors. This signaled the possibility of the involvement of other factors in the students’ decisions for the type of their major. Considering that the PWISEM students were more likely to remain in SM&E, it might be possible to speculate that the sense of community (Kahveci, 2004) or its absence was an implicit determiner in the students’ decisions.
CHAPTER 7

CONCLUSIONS AND THEIR IMPLICATIONS

Conclusions

The findings of this research are unique to the participants selected, yet the results tie to the science education literature tightly and supported implications for theory and practice, which I discuss in this chapter. By addressing the questions central to this research, the findings highlight the undergraduate women’s notions of gender and science, their experiences, interactions and contradictions in the SM&E fields, and their identification of themselves as future scientists. The findings also shed light on the social and cultural significance of the PWISEM as a program designed to enhance the participation of women in SM&E fields at college level. I also discuss possible standpoints by which the women’s underrepresentation problem could be approached within the contexts of programs like the PWISEM.

Becoming Women Scientists: Interactions and Contradictions

Although the findings about the significance of the PWISEM answer the “what” question in terms of key factors and their impact on women’s retention (Research Question 3), the “how” question addresses the way these women relate to the SM&E fields as future women scientists (Research Question 2) and uncovers the interactions and contradictions involved in their experiences (Research Question 1).

The participants and cases of this research enacted different science identities; yet, they all had parallel intentions about remaining in the SM&E and making careers. None of the women showed evidence of actively participating in reconstructing and transforming the social relations involved in SM&E. They conceptualized the men dominance in SM&E as dominance in terms of numbers, and not in terms of gendered components involved in scientific tools and practice. Echoing the Program, they
perceived “change” in the SM&E fields as more women participating in them, underlining liberal feminist objectives (Rosser, 1997; Scantlebury, 2002; Weedon, 2000). All three are prospective full participants in the community of science; however, their participation would only reproduce the overall picture of the unequal distribution of women and men scientists within certain careers and positions within these careers. Also, the hegemonic and androcentric nature of science (Lederman, 2003; Schiebinger, 1989; Seymour, 1995) would remain unchallenged. Contrasting Lena, although Carol and Reyna claimed or endorsed feminine identities, these identities were not feminist enough to participate in activism (Liss et al., 2004) to change the status quo in SM&E. While Lena fit well within the “less feminine” image of women in engineering and science (Seymour, 1995), Carol and Reyna tended to aim for careers/positions more compatible with their feminine identities, but less powerful and more marginal (Eisenhart & Finkel, 1998). In other words, the women in this research were more likely to internalize the status quo in these disciplines without actively challenging it.

The contradiction between the rules, or the culture, of SM&E and the women’s objects of becoming successful scientists remained unresolved. Although the PWISEM was a powerful mediating artifact with significant contribution to their objects via providing academic support and building sense of community and SM&E networks, issues such as challenging the masculine structure of science were out of its scope. The sense of community was more a means for achieving academic success than being helpful in approaching/solving conflicts in the SM&E fields in terms of gender, or encouraging feminist activism (Liss et al., 2004).

According to Liss et al. (2004), to participate in feminist activism, or collective action, having a feminist identity or identity as a strong woman is essential. Developing such an identity is possible through exposure to what feminism really means, positive opinion of the feminist movement, and support of feminist goals (Myaskovsky & Wittig, 1997), the evolution of which could be promising in contexts like PWISEM.

The Significance of the PWISEM

The first phase of the pilot study, my evaluation of the PWISEM at the end of the academic year 2002-2003 revealed that the Program provided a supportive environment
to its participants that encouraged success (for more detail see Kahveci, 2004). The freshmen participating in the PWISEM emphasized the sense of community as one of the best experiences they had in the Program, a community provided by living together in the residence hall. This community helped them to succeed in their majors through peer mentoring (by PWISEM upperclassmen) and supportive relationships. They also mentioned peer backing (a term the PWISEM freshmen used to refer to the supportive interactions among themselves), learning about the women scientists, mathematicians or engineers in the Colloquium lectures, and career panel discussions as very helpful to enhance their self-confidence in pursuing SM&E majors.

For me as researcher, this first phase of the pilot study represented the transition of the PWISEM context from evaluation to research site. In the second phase, I became more involved in the context and attended the Program’s events and activities, made contributions by holding a technology workshop, and communicated with and interviewed PWISEM students, Dr. Jones and other staff. The events and activities organized by the Program (i.e., Ropes course) played an important role in establishing the sense of community among its participants. Also, being in the Program was helpful in terms of getting academic support. This was possible through interacting with peers in the PWISEM, and with guest speakers (scientists) and staff (Dr. Jones, PWISEM Faculty Advisory Committee members, mentors, tutors). The opportunities provided through the Program (i.e., internships) enhanced the academic support for its participants the most.

The three PWISEM women who were the cases of this research provided invaluable insight into what the key factors of the Program were in terms of motivating and supporting women students in their intended SM&E majors. Besides emphasizing the academic support, they indicated that participating in the Program and living together as a community was very helpful for them to adjust to college as newcomers. Also, it was comforting to know that there were others who shared their academic challenges. This “company” made it easier to stay in their majors and keep themselves motivated.

The academic support provided through the Program was in the form of:
1. Mentorship/relationship with faculty and upperclassmen peers (Seymour, 1995): The Program provided opportunities for its participants and women faculty in the SM&E fields to interact in formal and informal mediums such as the Colloquium
course, career panel discussions, guest speaker lectures in the spring semesters, field trips, and “Brown Bag” lunch gatherings. By getting to know women (and men) scientists the PWISEM students joined the SM&E network (or the community of science), which Dr. Jones mentioned as being one of the goals of the Program. Also, each year Dr. Jones made available space in the residence hall for about five to ten sophomore PWISEM students to live with the freshmen. They were called peer leaders and their role was to mentor their first year peers.

2. Mentorship/relationship with “same level” (freshmen) peers: It was crucial for the young women to live together as a community in their first year. This helped them stay in the SM&E majors and keep themselves motivated since it was comforting to know there were others going through the same academic challenges. The PWISEM students often came together for academic mentoring and exchanging SM&E content knowledge. As I mentioned before, this type of academic support among the freshmen was called peer backing.

3. Internship opportunities and field trips: Through the Program the students were able to find internships, which offered them opportunities to participate in research, work with distinguished faculty/scientists, and gain career skills. The internship experiences also built new connections within the SM&E network, which were essential in terms of the young women’s success in their future careers. The purpose of the field trips to scientific facilities was to increase the awareness of the PWISEM students about SM&E in the real world, as well as about career opportunities. Both the internships and the field trips provided the students with a more realistic image of their fields as well as access to more authentic language and cultural practices of SM&E.

4. Tutoring: The PWISEM offered specific tutors in mathematics and chemistry. In addition, the Program had (limited) resources to appoint tutors for other courses in SM&E based on the students’ demand.

5. Awards: Dr. Jones organized awards ceremonies each year to present awards (including monetary) to the Program’s most successful participants and to celebrate their academic achievements. These ceremonies were funded by a club
supporting women in science. The recognition of the students for their academic achievements enhanced students’ motivation and success in the SM&E majors.

The first two aspects of academic support and, to some extent, the third one emphasized the interactions and relationships made available through the PWISEM. The strong emphasis on relationships and connection in the Program’s approach underlines feminist assumptions of the importance of “responsibility and care in relationships” (Gilligan, 1982, p.173), and their value in *women’s ways of knowing* (Belenky et al., 1986). By focusing on expanding the students’ SM&E network and improving the interactions among the members of this network—both at student and faculty level—Dr. Jones seemed to recognize the positive effect of involving feminist views in the Program’s approach.

The network established through the PWISEM consisted mostly of students, scientists, and faculty members who were women. Thus, the Program’s approach embraced a psychoanalytic feminist perspective, which argues that there are closer relationships among women than those between women and men (Rosser, 1997). Also, given that the first-year students were required to live in a residence hall as a women-centered community, it involved a radical feminist approach. In other words, the PWISEM emphasized strong women-women relationships and living in women-only environment, and fulfilled its role of fostering the participation and retention of women students in the SM&E majors, a liberal feminist goal (Rosser, 1997; Scantlebury, 2002; Weedon, 2000), by means of psychoanalytic feminism and radical feminism. In such liberal programs for change the emphasis is put on women to take up opportunities in SM&E and not on the masculine culture of these fields (Cronin & Roger, 1999). Hence, other feminist aspects than liberal feminist have little impact on the approaches of programs like PWISEM and play a supplementary role.

The Program was characterized by these three feminist theory strands. By contrast, it did not involve a socialist feminism aspect because the target population was not specifically women with low income/socioeconomic status family background. It also did not focus on women of color, so there was not an African American or racial/ethnic feminism aspect. The Program by no means embodied an essentialist perspective because if its founders had believed in innate differences between women and men (favoring men
in terms of science abilities) they would have been unlikely to propose this Program. On the other hand, in the Program’s agenda, there were no specific activities directly relating to SM&E experimentation to compensate for the women’s lack of science experiences caused by their upbringing. Thus, an existentialist feminism perspective was not a Program component. Finally, because the PWISEM was a liberal feminist project with emphasis on strong relationships, it unified the women’s needs, and could not be identified as postmodern feminist. A program with postmodern feminist perspective would recognize that women have various backgrounds and unique experiences, and employ multiple approaches (such as those just mentioned) in order to relate to each (Rosser, 1997).

Central to this research, the PWISEM achieved its liberal feminist goal of fostering the participation and retention of its participants in the SM&E majors. According to the pre-posttest comparison discussed in Chapter 6, after one academic year significantly more PWISEM students than HGC students (both women and men) remained in the SM&E fields. Noticeably, there were no significant differences among the groups in terms of interest, confidence, and GPA. Such a result signaled that the interactions, relationships, the building of SM&E network and the sense of community, all aspects of the PWISEM, might be the leading factors that its participants made easier decisions to remain in their intended SM&E majors. In other words, the Program had positive impact on the women students’ retention but it was primarily through building supportive networks and not through other means such as enhancing their interest, confidence, or GPAs.

**Highlights from the Pretest-Posttest Comparisons**

All of the students from both the PWISEM and HGC groups were alike in terms of their responses to the majority of the items in the tests with a few minor exceptions. One of these exceptions was that in their views of scientists, the HGC men students were different than the two women student groups in the beginning of the academic year; yet, they became alike at the end. This shift in their view signaled the positive impact of the university SM&E education on the image of scientists. The second area with difference among the groups was issues related with nuclear energy and electricity. A third one was
the students’ differential BSRI categorization. Significantly more men students categorized as masculine at the end of the academic year signaling their “compatibility” with the masculine culture of SM&E. Yet ironically, many of them decided not to pursue SM&E majors, which was an indication that other factors were involved in their decisions.

In the pretest, the HGC men student group had differed from the two women groups in the sense that the men students had a tendency to agree that “scientists are apt to be odd and peculiar people.” According to the posttest, the three groups converged with respect to their image of scientists after one academic year, which was an image more integrated with the ordinary society (scientists as normal people). While there was no statistically significant difference in the pretest among the groups, the PWISEM students scored consistently less interested and poorly informed about issues related with nuclear energy and electricity as compared with the other two groups in the posttest.

The most prominent results of the students’ BSRI categorization were those of the men students. Many men from the androgynous category switched to the near feminine and masculine categories after one academic year. The statistically significant relationship indicated that at the end of the academic year there were fewer men who were categorized as androgynous and more men in the masculine category compared with the two women groups. Such a result implied that men were more likely to become masculine, or “prove” their manliness in the weed-out system of the SM&E fields, as opposed to the young women from both the PWISEM and HGC groups, to whom such a process was totally obscure (Seymour, 1995).

Seymour (1995) describes the weed-out system as “an institutionalized national (possibly international) teaching and learning system which has evolved over a long period as an approved way to induct young men into the adult fraternities of science, mathematics, and engineering” (p. 459). The rules of this system stem from the socially established traditional masculine norms, thus relating to men and obscure to women. The young men in college are expected by faculty to “prove” their manliness by standing up to “the harshness of their teaching methods, curriculum pace, and assessment system in introductory classes” (p. 461). This is a meaningless message to the women minority. Yet, according to the pre- and posttest results, many of the men in this research chose not
to pursue these fields. Their decision was despite the fact that they succeeded to “prove” their manliness as the BSRI categorization revealed. It was also in spite of the small size of their classes within the Honors program where there could be a great potential to establish strong relationships among faculty and students. Their tendency to pursue other fields than SM&E implied factors that discouraged both men and women students from entering these realms such as impersonal teaching and learning environments.

As Seymour (1995) suggests, “some aspects of the learning environments in which many women feel most comfortable—particularly those which are interactive, cooperative, experiential, and learner-focused—are also congenial to many young men” (p. 470). According to her, changing the pedagogy from teaching-centered to learner-centered approach promises to reduce the loss of both women and men students from the SM&E majors. In radical feminists’ view (such as Roxanne Dunbar) the aspects of the more appealing learning environments that Seymour listed point out the difference of women than men. Women have “certain ‘maternal traits’ such as caring for others, flexibility, non-competitiveness, and cooperativeness,” which “are essentially humane and must be the moral basis for a new society” (Donovan, 2000, p. 156).

For example, some argue that women tend to value connection and interpersonal relationships more than men (Gilligan, 1982), and that is their way of learning (Belenky et al., 1986). Yet, science education environments or professional contexts beyond academe, which are interactive and cooperative, also relate to many young men (Seymour, 1995). Besides encouraging interactions and cooperation, gender-inclusive science teaching could embrace social constructivist principles such as facilitating personal interests and previous experiences (Barton, 1998; Roychoudhury et al., 1995). All these aspects and similarly, fostering a “learning community,” engaging “active learning,” and requiring students to “make sense” of observations and concepts, are in fact ideas suggested by the NRC (1996) for reform-based science teaching and learning.
Implications

Theory and Practice

Explicit Transformation of SM&E: Raising Feminist Awareness

Rather than encouraging girls and young women to “adapt to fit” (Cronin & Roger, 1999, p. 650) in SM&E, within the explicit transformation approach I argue that women should enter these disciplines with awareness of reform. This research reveals the important potential initiatives programs like PWISEM might have in solving the gender problem in SM&E. They might succeed not only in increasing the representation of women in science (equality) but also in reaching gender equity by explicitly challenging the gender bias.

Instead of placing the emphasis of change on women and leave the SM&E culture as is (Cronin & Roger, 1999) programs like PWISEM can be powerful sites of raising awareness of the gender bias inherent in science. The sense of community/solidarity and the SM&E networks within such liberal programs, typically used for providing academic support, can become effective means of critically approaching the culture of SM&E. Specific strategies may include triggering a debate toward more informed understanding of the women problem in SM&E among women and men faculty involved in the SM&E network of the programs.

In addition, these programs may work toward developing the college women’s feminist identities (Liss et al., 2004) by exposing them to what feminism and feminist theory means, and ensuring their support of feminist goals, positive opinion of the feminist movements, recognition of discrimination against women and beliefs in collective action (Myaskovsky & Wittig, 1997). This is not to argue a woman-centered or gynocentric science (Hubbard, 2001) or science teaching, however, it is an important step in assisting students and also faculty to recognize the value-embeddedness of scientific practice (NAS, 1995) as well as its teaching (Kahle & Lakes, 1983). Many report that acknowledging gender bias in science and in the teaching of science, and taking actions toward eliminating this bias would benefit both genders. These scholars suggest that establishing more interactive, cooperative, authentic, experiential, learner-focused, and gender-sensitive learning environments accommodate the needs of both women and men.
students (Bianchini et al., 2003; Cronin & Roger, 1999; Howes, 2002; Rosser, 1994; Roychoudhury et al., 1995; Seymour, 1995). For example, facilitating personal interest and taking into account previous experiences is promising to make the teaching and learning relevant to everyone. At the very least, it is not likely that men students’ learning would be impeded by the presence of these aspects.

Finally, the explicit strategy of transformation needs to involve men students and faculty. Their participation would enrich gender equity discussions within contexts of programs such as PWISEM and also raise the awareness of both women and men. However, to what extent men would be willing to participate in feminist activism is an open question.

*Implicit Transformation of SM&E: Departing from Interwoven Feminist Aspects*

Another implication of this research speaks to feminist theory and its role in redefining the culture in SM&E through contexts like PWISEM in a more implicit way. While the importance of women’s equality to men in the SM&E fields should not be questioned, it is also critical that the masculine culture of SM&E is challenged, “redefined and reconstructed to include us all” (Rosser, 1994, p. 14). Besides explicitly challenging the masculine SM&E culture, I suggest that there can be more implicit ways of transformation.

Like Rosser’s (1997) conclusion from her examination of 80 programs and projects designed for girls and women, the PWISEM states liberal feminist goals. As Rosser also found, most programs and projects include other feminist theory aspects. Besides having a liberal feminist approach, the PWISEM involves radical feminist and psychoanalytic feminist perspectives because its emphases are on living together as a community in women-only environment, having guest speakers and other staff mostly consisting of women, and establishing support networks.

Normally, such composition of feminist aspects is unexpected since liberal feminism is first-wave feminism based on *sameness* with men, and radical and psychoanalytic feminisms are second-wave feminist strands arguing women’s *difference*. Historically, the latter built on the former by appropriating it. However, I argue that to change the culture of SM&E more women should be encouraged to enter these fields *and*
these women should have the qualities of future scientists in a desired, reformed SM&E. In other words, the programs should not “teach” their participants the norms in traditional SM&E, instead they should emphasize the differences. By means of extensive SM&E networks involving connection and close relationships both at the student and faculty level, and encouraging the women primarily in this way, like PWISEM did, these programs may possibly contribute to the establishing of more personalized education in SM&E and more inclusive culture of science. For example, such programs may work toward enhancing personal pedagogical relationships among faculty and students. Finally, in such an approach, it is essential that the number of women (or men) faculty and students valuing more interactive learning environments in SM&E increases. I believe that taking action in interstitial communities of practice like PWISEM and increasing the number of these communities, as well, is promising in terms of having impact on the entire community of science in the long term.

In contrast with Liss’ et al. (2004) argument that having a feminist identity or at least a strong identity as a woman are important for feminist activism, such a transformation is more implicit. It is implicit in the sense that this activism is not necessarily feminist but is still activism. The “feminist” label may imply negative feminist stereotypes to many women and men (Liss, O'Connor, Morosky, & Crawford, 2001), thus it is possible that taking action without employing this label would be more efficient in reaching greater populations (both women and men) and reforming SM&E. As much as such an approach for transformation may sound like feminist activism, it is not necessarily so. It is about changing the status quo in the SM&E realms, and bringing in other qualities than those of the Western and white man. Feminist standpoint is just the “political point of departure” (Alcoff, 1988, p. 432) for transformation, and in the absence of that departure the gender bias in SM&E would not have even been noticed. The ultimate goal is simply to make SM&E more inclusive and more appealing to all.

As I suggested above, although it may seem contradictory, within the contexts of programs such as PWISEM the aspects of sameness and difference feminisms can be effectively combined in solving the gender problem in science. Such a position may turn out to be the only successful approach to involve men in solving the gender problem in SM&E. “This is necessary if men are to produce more than the male supremacist ‘folk
belief about themselves and the world they live in to which female feminists object” (Harding, 1993, pp. 67-68).

If we are to change the nature of science, I would argue that the scope and the titles of these programs need to be expanded to include men students (and faculty), as well. For example, the PWISEM might become PWMISEM, or Program for Women and Men in Science, Engineering and Mathematics. Men students, too, might be invited to participate in the Program. This is important also because the findings of this research imply less enthusiasm for men students than women to pursue a SM&E major. All things being equal, such as similar interest and confidence in pursuing these majors/careers, the sense of community and the networks could make difference in the retention rates of men students, as well. More men faculty might be invited to join the network and to be guest speakers in the Program’s lectures. Also, instead of having predominantly women faculty as members of the Faculty Advisory Committee, the PWISEM could expand its vision to have and value the contributions of many men faculty. Relevantly, women and men faculty could periodically and alternately serve as the Program Director. As long as programs like PWISEM are representative of half of the student and faculty population, there is little chance for success in reforming SM&E to include all. I argue that in the implicit transformation approach communication and cooperation of both genders is a significant component.

**Toward Implicit Transformation**

Figure 7-1 represents how the implicit and explicit approaches of transformation are similar to and different from each other. In the explicit approach, feminist activism is strongly emphasized and feminist awareness of the gender bias in science is raised. The implicit approach is primarily different in the sense that it does not include these two aspects. Instead of explicitly calling for feminist action, the implicit approach concentrates on working to enhance other qualities than those of the Western and white man, via means of extensive SM&E networks. Since its focus is on broad networks, the implicit approach utilizes sameness feminism aspects, as well. On the other hand, the explicit approach is not as much concerned with networking. Thus, it is not as open as the
implicit approach to involving men students and faculty in the process of transforming SM&E.

Figure 7-1. Contrast of the aspects involved in explicit and implicit approaches of transformation.

I suggest that the implicit approach of transformation is more powerful. First of all, it does not label itself as feminist and is inclusive of both genders. Secondly, because it interweaves the aspects of two traditionally opposite feminist strands, the implicit approach can be influential on larger populations. Finally, its focus on interactions and networking is promising to ultimately reach the entire community of science.

Improving pedagogy and student-faculty relationships. The participants of this research experienced difficulties in establishing personal relationships with their professors. They also had negative reactions toward traditional didactic teaching in large classrooms. The monotonous and unappealing lecturing methods and the unapproachable position of most of their professors hindered the women’s learning. For Reyna, her professors represented a negative image of a biologist, someone she did not want to be. Both Carol and Reyna sought tutors’ aid, which they could not get from their professors.
This research once again advocates pedagogical transformation with emphasis on faculty for more personal pedagogical relationships with their students. Programs such as PWISEM might play an important role in this process as they can reach many faculty members in SM&E by expanding their networks.

Another strategy would be to inform institutions about the vital role professor-student relationships beyond the classroom setting play in the students’ success and retention in SM&E fields, and prompt for structural rearrangements regarding the SM&E professors’ loads. Also, concerning the need for both pedagogical transformation and improvement of student-professor relationships in the SM&E fields, I would argue that science education faculty, who are professionally more aware of these needs, must have tight connections with faculty from SM&E departments and with programs like PWISEM. Moreover, contexts like those of the PWISEM may become powerful platforms where science and science education faculty can professionally interact with a common goal, ensuring women’s (and marginal others’) participation in SM&E.

Theory

Situated Learning/Legitimate Peripheral Participation

This research informs Lave and Wenger’s (1991) theory of situated learning/legitimate peripheral participation regarding newcomer interactions and their role in participating in the community of practice. Through the findings it emerges that the interactions among the newcomers in the PWISEM are, if not stronger, at least as strong as the interactions between the newcomers and the old-timers/full participants. Also, the newcomers’ relations with one another have positive impact on their participation in the SM&E, not only through academic support but also through emotional comfort. As I mentioned before, it was comforting for the first-year PWISEM students to know that there were others who shared their academic challenges.

Speaking to theory, to become full participants in communities of practice newcomers may master the needed knowledge and skills by one another’s means as well as share other aspects of their peripheral participation. My work suggests that in the theory of situated learning (Lave & Wenger, 1991) newcomer interactions are a key aspect and so, deserve a stronger emphasis and broader elaboration. I argue that
considering newcomer interactions only in terms of being effective means for circulation of knowledge (Lave & Wenger, 1991) is limiting. Other aspects involved in the newcomer interactions, which are affective rather than strictly rational, play a significant role in their prospective full participation in the community of practice. Newcomers characterize a powerful sub-community with cultural and social significance within the community of practice.

Future Research

An active/interventionist research in the context of a program like PWISEM may aim to foster implicit transformation of SM&E in the light of the implications of this research. Given the emphasis on broad networks and the building of strong connections within SM&E, such a research would be long-term and extensive.

Considering the lower retention among the non-PWISEM students in SM&E a further qualitative study may investigate the factors contributing to these students’ decisions to switch out of SM&E majors. Of key interest would be the men students’ rationale to switch, since they are supposedly more likely to prove their “manliness” and fit smoothly within the masculine culture of science.

A longitudinal study may investigate the impact of a program for college women with stronger emphasis on difference feminism on women’s participation in SM&E. It would be of primary interest to research the extent to which the culture of SM&E can be altered through such an initiative. A study like this may imply a strong need of collaboration with men faculty in SM&E.

Another long-term study may explore the students’ journey toward full participation in SM&E and the afterwards. Such a research may look into the science identities of the students and how these identities change towards and during full participation. The impact programs like PWISEM have on SM&E and SM&E participation would emerge more clearly over time.

More research can be conducted on the views of men and women SM&E faculty on personal pedagogical relationships with their students. Any differences in attitudes with respect to gender may further be examined and possible collaboration with science education faculty may be discussed.
APPENDIX A - Human Subjects Committee Approval

Florida State University
Office of the Vice President
For Research
Tallahassee, Florida 32306-2763
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Human Subjects Committee

Date: 8/19/2003

Ajda Kahveci
2704 Oak Park Court
Tallahassee, FL 32308

Dept.: Middle and Secondary Education

From: David Quadagno, Chair

Re: Use of Human Subjects in Research
How Undergraduate Female Students Persist in Their Science Majors: An Activity

Theoretical Study

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and two members of the Human Subjects Committee. Your project is determined to be exempt per 45 CFR § 46.101(b) 2 and has been approved by an accelerated review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If the project has not been completed by 8/18/2004 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. Also, the principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is IRB00000446.

Cc: Dr. Penny Gilmer
HSC No. 2003.396
APPROVAL MEMORANDUM (for change in research protocol)
From: the Human Subjects Committee

Date: 8/25/2003

Ajda Kahveci
2704 Oak Park Court
Tallahassee, FL 32308

From: David Quadagno, Chair

Dept: Middle and Secondary Education

Re: Use of Human subjects in Research
Project entitled: How Undergraduate Female Students Persist in Their Science Majors: An Activity Theoretical Study

The memorandum that you submitted to this office in regard to the requested change in your research protocol for the above-referenced project have been reviewed and approved. Thank you for informing the Committee of this change.

A reminder that if the project has not been completed by 8/18/2004, you must request renewed approval for continuation of the project.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is IRB00000446.

cc: Dr. Penny Gilmer
chgapp.doc
APPLICATION NO. 2003.396
Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2763
(850) 644-8633· FAX (850) 644-4392

REAPPROVAL MEMORANDUM

Date: 9/13/2004

To:
Ajda Kahveci
2704 Oak Park Court
Tallahassee, FL 32308

Dept.: Middle and Secondary Education

From: John Tomkowski, Chair

Re: Reapproval of Use of Human subjects in Research:
    How Undergraduate Female Students Persist in Their Science Majors: An Activity
    Theoretical Study

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 8/18/2005 please request renewed approval.

You are reminded that a change in protocol in this project must be approved by resubmission of the project to the Committee for approval. Also, the principal investigator must report to the Chair promptly, and in writing, any unanticipated problems involving risks to subjects or others.

By copy of this memorandum, the Chairman of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols of such investigations as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

Cc: Dr. Penny Gilmer
HSC No. 2004.648-R
APPENDIX B - Informal Conversation Form

ENTRY OPINION FORM / PWISEM
29-30 September, 2003
Ajda Kahveci

First Name ____________________________ Last Name ____________________________

How would you like to be called?

Place of Birth (City and State if U.S.) ____________________________

Race (I will use the information for the purpose of having interviewees of different backgrounds)

So far, what did you like most about the PWISEM?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

So far, what did you like least about the PWISEM?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

So far, are the science/mathematics courses at [the University] matching your expectations or not? How?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Would you be willing to participate in monthly (or every 1.5 month) interviews until the end of the spring semester for my PhD dissertation about “women and science”? (Your identity and anything related with your identity will be kept confidential and only known by me).

________________________________________________________________________

* All personal information will be kept confidential.
APPENDIX C - Sample Interview Protocol

1. Why do you prefer to pursue a major in science or engineering rather than majoring in any other field?
2. How have you got interested in science or engineering? What influenced you?
3. How interested are you in pursuing a major in science or engineering?
4. How confident do you feel about pursuing a major in science or engineering?
5. How do you describe science?
6. How do you describe a scientist? Please draw a scientist.

7. How do you see yourself as a scientist?
   a. Do you think there are certain characteristics that you will need to develop in order to be a good scientist or engineer? If yes, what are these? If you believe that you already have them, please tell about them to me.
   b. What do you imagine your life will look like when you become a scientist or engineer?
   c. What is your eventual goal in becoming a (woman) scientist? Is this goal any different given that you are a woman?

8. Why did you choose to participate in the PWISEM?
9. So far, what did you like most about the PWISEM? Why?
10. So far, what did you like least about the PWISEM? Why?
11. How do you interact with your peers in the program and with the upperclassmen PWISEM students? Are these interactions productive in terms of achieving your goals as a science or engineering major? How?
12. What do you think about the PWISEM Colloquium and the associated research facilities trips? Is there anything they contribute to you as a student intending to major in science or engineering? If so, what?
13. So far, are the science/mathematics courses at [the University] matching your expectations or not? How?
   a. So far, what do you like and dislike about the science/mathematics courses at [the University]?
14. Considering all of these (the above), can you think of any factors that distract you in your way of becoming a scientist, engineer, or mathematician?

15. Why do you think there are fewer women than men in the science, math, and engineering fields?
16. Have you ever felt any discrimination or discomfort based on your gender in the context of science/mathematics courses?
17. Do you think in the broader scientific community it is important that women participate in science? Why / why not?
   a. Do women add anything unique to science?

APPENDIX D - Interview Consent Form

Interview Consent Form

Dear Participant,

I am a graduate student under the direction of Professor Dr. Sherry A. Southerland in the Department of Middle and Secondary Education, and Professor Dr. Penny J. Gilmer in the Department of Chemistry and Biochemistry, at Florida State University. I am conducting a research study to understand how women students participating in the Women In Mathematics, Science and Engineering (WIMSE) program retain and succeed in their science and science related majors.

I am requesting your participation, which will involve participating in a series of interviews throughout the academic year 2004-2005. The interviews will be done monthly or more frequently if there is a need. Each interview will take about 20-30 minutes. The interviews will be audiotaped and tape recordings transcribed verbatim. Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty; it will not affect your grade. The results of the research study may be published, but your name will not be used. The questionnaires are confidential to the extent allowed by law.

Although there may be no direct benefit to you, the possible benefit of your participation is helping to expand theory and inform practice regarding science education.

If you have any questions concerning the research study, please call me at (850) 575-4861, or send me an e-mail at aak3453@fsu.edu. You may also call Dr. Sherry A. Southerland at (850) 645-4667 or e-mail her at souther@coe.fsu.edu, or Dr. Penny J. Gilmer at (850) 644-4026 or e-mail her at gilmer@chem.fsu.edu.

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Vice President for the Office of Research at (850) 644-8633. Office of Research is located at "Innovation Park, 109 Morgan Building, Tallahassee, FL 32306".

Sincerely,

Ajda Kavvuci
Doctoral Student
Department of Middle and Secondary Education
Florida State University

* * * * * * *

I give my consent to participate in the above study. There are no foreseeable risks or discomforts if I agree to participate in this study. I understand that I will be tape recorded by the researcher. These tapes will be kept by the researcher in a locked filing cabinet. I understand that only the researcher will have access to these tapes and that they will be destroyed by August 30, 2010.

__________________________ (signature) __________________ (date)
**APPENDIX E - The Pretest**

**SCIENCE AND TECHNOLOGY ATTITUDES SURVEY I**

* Please circle the option that best describes your agreement/disagreement with each of the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>1- strongly agree</th>
<th>2- agree</th>
<th>3- disagree</th>
<th>4- strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- It is not important for me to know about science in my daily life.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2- A scientist usually works alone.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3- Scientific work is dangerous.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4- Scientific researchers are dedicated people who work for the good of humanity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5- Scientists don’t get as much fun out of life as other people do.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6- Scientists are helping to solve challenging problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7- Scientists are apt to be odd and peculiar people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8- Most scientists want to work on things that will make life better for the average person.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9- Scientists are not likely to be very religious people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10- Scientists have few other interests but their work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11- Different scientists may get different solutions to the same problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>12- Something that is proven by using the scientific method is a fact, and therefore no longer subject to change.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13- Scientists use their creativity and imagination during and after data collection.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

* Please circle the option that best describes your situation for each of the following issues:

<table>
<thead>
<tr>
<th>Issue</th>
<th>LOW</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>14- Rate your current <strong>level of interest</strong> in pursuing a major in science, mathematics, or engineering.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15- Rate your current <strong>level of confidence</strong> about your ability to learn science.</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

16- **Concerning your program of study (please check the option that best describes your situation):**

- [ ] You are certain of your academic major.
- [ ] You have narrowed down your academic major to several.
- [ ] You need assistance in deciding.
- [ ] You do not know at the moment, but you will decide on your own.
**17-** How well each of the personality characteristics below describes you? Please answer by using the scale given.

<table>
<thead>
<tr>
<th>Personality Characteristic</th>
<th>Scale: Never or almost never true</th>
<th>Usually not true</th>
<th>Sometimes but infrequently true</th>
<th>Occasionally true</th>
<th>Often true</th>
<th>Usually true</th>
<th>Always or almost always true</th>
</tr>
</thead>
<tbody>
<tr>
<td>self-reliant</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
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<tr>
<td>yielding (giving up)</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>helpful</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>defends own beliefs</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>cheerful</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>moody</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>independent</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>shy</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>conscientious</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>athletic</td>
<td>1 2 3 4 5 6 7</td>
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<td>affectionate</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>theatrical</td>
<td>1 2 3 4 5 6 7</td>
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<td>assertive</td>
<td>1 2 3 4 5 6 7</td>
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<td>flatterable</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>happy</td>
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<td>strong personality</td>
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<td>loyal</td>
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<tr>
<td>unpredictable</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>forceful</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>feminine</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>reliable</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>analytical</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>sympathetic</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>jealous</td>
<td>1 2 3 4 5 6 7</td>
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<td>has leadership abilities</td>
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<td>sensitive to the needs of others</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>truthful</td>
<td>1 2 3 4 5 6 7</td>
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<td></td>
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<tr>
<td>willingness</td>
<td>1 2 3 4 5 6 7</td>
<td>ambitious</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>understanding</td>
<td>1 2 3 4 5 6 7</td>
<td>gentle</td>
<td>1 2 3 4 5 6 7</td>
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<td></td>
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</tr>
<tr>
<td>secretive</td>
<td>1 2 3 4 5 6 7</td>
<td>conventional</td>
<td>1 2 3 4 5 6 7</td>
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</tr>
</tbody>
</table>

* There are a lot of issues in the news, and it is hard to keep up with every area. Please circle the option that best describes your situation for each of the following issues by using the scale given:

<table>
<thead>
<tr>
<th></th>
<th>1- very interested</th>
<th>2- moderately interested</th>
<th>3- not at all interested</th>
</tr>
</thead>
<tbody>
<tr>
<td>18- Issues about new scientific discoveries</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>19- Issues about the use of new inventions and technologies</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>20- Issues about new medical discoveries</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>21- Issues about space exploration</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>22- Issues about environmental pollution</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>23- Issues about the use of nuclear energy to generate electricity</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

* Please circle the option that best describes your situation for each of the following issues by using the scale given:

<table>
<thead>
<tr>
<th></th>
<th>1- very well informed</th>
<th>2- moderately well informed</th>
<th>3- poorly informed</th>
</tr>
</thead>
<tbody>
<tr>
<td>24- Issues about new scientific discoveries</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>25- Issues about the use of new inventions and technologies</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>26- Issues about new medical discoveries</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>27- Issues about space exploration</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>28- Issues about environmental pollution</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>29- Issues about the use of nuclear energy to generate electricity</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

* Please circle the option that best describes your answer to each of the following questions:

<table>
<thead>
<tr>
<th></th>
<th>1- very often</th>
<th>2- often</th>
<th>3- usually</th>
<th>4- sometimes</th>
<th>5- never</th>
</tr>
</thead>
<tbody>
<tr>
<td>30- Used a word processing program (e.g. MS Word)?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>31- Used a computerized spreadsheet (e.g. MS Excel)?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>32- Used a Web page building program (e.g. MS FrontPage)?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>33- Used a presentation graphics program (e.g. MS PowerPoint)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>34- Sent/received an e-mail message?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
35- Used the World Wide Web (WWW) to search for information about a scientific or technological topic or problem?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

36- Played a computer game?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

37- Please check the statement below that best describes your computer skills:

- [ ] Novice (have used computer but not on a regular basis)
- [ ] Experienced (use computer regularly for word processing and/or Internet exploration)
- [ ] Expert (have used computer for more than word processing and/or Internet exploration)

* In deciding to participate in the PWISEM, how important to you was each of the following reasons? Please circle the option that best describes your answer for each of the statements.

<table>
<thead>
<tr>
<th>Reason</th>
<th>1- very important</th>
<th>2- somewhat important</th>
<th>3- not important</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1- To be in a safe environment away from home</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>P2- The dorm provided looked nice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>P3- To learn more about science/mathematics/engineering</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>P4- My parents wanted me to do so</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>P5- To have it on my resume</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>P6- A friend previously in the program recommended me</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>P7- To be in a supportive environment for women in science/math/engineering</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>P8- The opportunities of the program attracted me</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

38- Please fill out the following information about yourself:

The last 6 digits of your Social Security number:

[ ] [ ] [ ] [ ] [ ] [ ]

Age: _____ Intended major: __________________________________________

Do you have computer at home? (Please check)  [ ] Yes  [ ] No

How many mathematics and science courses did you take in high school? (Please check)

- [ ] 1- 4  - [ ] 5 - 9  - [ ] 10 - 15  - [ ] More than 15

* In your intention/decision to pursue a major in science/mathematics/engineering, how influential was each of the following factors? Please circle the option that best describes your answer for each of the statements.
<table>
<thead>
<tr>
<th></th>
<th>1- very influential</th>
<th>2- somewhat influential</th>
<th>3- not influential</th>
</tr>
</thead>
<tbody>
<tr>
<td>39-</td>
<td>Mother encouragement</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>40-</td>
<td>Father encouragement</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>41-</td>
<td>Other family member(s) encouragement</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>42-</td>
<td>Teacher(s) encouragement</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>43-</td>
<td>Media</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>44-</td>
<td>Own interest</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Dear Participant,

I am a graduate student under the direction of Professor Dr. Sherry A. Southerland in the Department of Middle and Secondary Education, and Professor Dr. Penny J. Gilmer in the Department of Chemistry and Biochemistry, at Florida State University. I am conducting a research study to understand how women students participating in the Women In Mathematics, Science and Engineering (WIMSE) program retain and succeed in their science and science related majors.

I am requesting your participation, which will involve answering this questionnaire in the beginning and at the end of the Fall 2003 semester, and at the end of the Spring 2004 semester. It will take about 20 minutes each time to respond. If you agree, you may participate in a series of interviews throughout the year, which will take about 30-45 minutes each. Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty; it will not affect your grade. The results of the research study may be published, but your name will not be used. The questionnaire is confidential to the extent allowed by law. The last 6 digits of your social security number will be used as a pseudonym.

Although there may be no direct benefit to you, the possible benefit of your participation is helping to expand theory and inform practice regarding science education.

If you have any questions concerning the research study, please call me at (850) 575-4861, or send me an e-mail at aak3453@fsu.edu. You may also call Dr. Sherry A. Southerland at (850) 645-4667 or e-mail her at southerl@coe.fsu.edu, or Dr. Penny J. Gilmer at (850) 644-4026 or e-mail her at gilmer@chem.fsu.edu.

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Vice President for the Office of Research at (850) 644-8633. Office of Research is located at "Innovation Park, 109 Morgan Building, Tallahassee, FL 32306".

Sincerely,

Ajda Kahveci
Doctoral Student
Department of Middle and Secondary Education
Florida State University

* * * * * * *

I give my consent to participate in the above study. There are no foreseeable risks or discomforts if I agree to participate in this study. I understand that I will be tape recorded by the researcher. These tapes will be kept by the researcher in a locked filing cabinet. I understand that only the researcher will have access to these tapes and that they will be destroyed by August 30, 2010.

________________________ (signature) ______________________ (date)
Dear Participant,

I am a graduate student under the direction of Professor Dr. Sherry A. Southerland in the Department of Middle and Secondary Education, and Professor Dr. Penny J. Gilmer in the Department of Chemistry and Biochemistry, at Florida State University. I am conducting a research study to understand how women students participating in the Program for Women In Science, Engineering, and Mathematics (PWISEM) retain and succeed in their science and science related majors.

I am requesting your participation, which will involve answering this questionnaire in the beginning and at the end of the Fall 2003 semester, and at the end of the Spring 2004 semester. It will take about 20 minutes each time to respond. Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty; it will not affect your grade. The results of the research study may be published, but your name will not be used. The questionnaire is confidential to the extent allowed by law. The last 4 digits of your social security number will be used as a pseudonym.

Although there may be no direct benefit to you, the possible benefit of your participation is helping to expand theory and inform practice regarding science education.

If you have any questions concerning the research study, please call me at (850) 575-4861, or send me an e-mail at aak3453@fsu.edu. You may also call Dr. Sherry A. Southerland at (850) 645-4667 or e-mail her at southerl@coe.fsu.edu, or Dr. Penny J. Gilmer at (850) 644-4026 or e-mail her at gilmer@chem.fsu.edu.

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Vice President for the Office of Research at (850) 644-8633. Office of Research is located at “Innovation Park, 109 Morgan Building, Tallahassee, FL 32306.”

Return of the questionnaire will be considered your consent to participate. Thank you.

Sincerely,

Ajda Kahveci
Doctoral Student
Department of Middle and Secondary Education
Florida State University
APPENDIX G - The Posttest

SCIENCE ATTITUDES SURVEY II

1- Please fill out the following information about yourself:

First name: ___________________ Last Name: ________________ Middle Initial: __

The last 4 digits of your Social Security number: ________________________

Age: _______ Preferred e-mail address: ________________________________

Sex:  [ ] Male  [ ] Female

Status:  [ ] Freshman  [ ] Sophomore  [ ] Junior  [ ] Senior

Major/Intended major: ________________________

Are you:

[ ] White/Caucasian  [ ] African American/Black  [ ] Mexican American/Chicano
[ ] American Indian  [ ] Asian American/Asian  [ ] Puerto Rican
[ ] Other: ________________________  [ ] Other Latino

* Please circle the option that best describes your agreement/disagreement with each of the following statements:

<table>
<thead>
<tr>
<th></th>
<th>1- strongly agree</th>
<th>2- agree</th>
<th>3- disagree</th>
<th>4- strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>2- It is not important for me to know about science in my daily life.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3- A scientist usually works alone.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4- Scientific researchers are dedicated people who work for the good of humanity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5- Scientists are helping to solve challenging problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6- Scientists are apt to be odd and peculiar people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7- Most scientists want to work on things that will make life better for the average person.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8- Scientists are not likely to be very religious people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9- Scientists have few other interests but their work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10- Something that is proven by using the scientific method is a fact,</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
and therefore no longer subject to change.

11- Scientists use their creativity and imagination during and after data collection.

* Please circle the option that best describes your situation for each of the following issues:

<table>
<thead>
<tr>
<th></th>
<th>LOW</th>
<th></th>
<th></th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>12- Rate your current level of interest in pursuing a major in science, mathematics, or engineering.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13- Rate your current level of confidence about your ability to learn science.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

14- Concerning your program of study (please check the option that best describes your situation):

- [ ] You are certain of your academic major.
- [ ] You have narrowed down your academic major to several possibilities.
- [ ] You need assistance in deciding.
- [ ] You do not know at the moment, but you will decide on your own.

* There are a lot of issues in the news, and it is hard to keep up with every area. Please circle the option that best describes your situation for each of the following issues by using the scale given:

<table>
<thead>
<tr>
<th></th>
<th>1- very interested</th>
<th>2- moderately interested</th>
<th>3- not at all interested</th>
</tr>
</thead>
<tbody>
<tr>
<td>15- Issues about new scientific discoveries</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>16- Issues about the use of new inventions and technologies</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>17- Issues about environmental pollution</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>18- Issues about the use of nuclear energy to generate electricity</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

* Please circle the option that best describes your situation for each of the following issues by using the scale given:

<table>
<thead>
<tr>
<th></th>
<th>1- very well informed</th>
<th>2- moderately well informed</th>
<th>3- poorly informed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Issues about new scientific discoveries</td>
<td></td>
<td>Issues about the use of new inventions and technologies</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------</td>
<td>---</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>19-</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>24-</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

25- How well each of the personality characteristics below describes you? Please answer by using the scale given.

1- Never or almost never true  
2- Usually not true  
3- Sometimes but infrequently true  
4- Occasionally true  
5- Often true  
6- Usually true  
7- Always or almost always true

<p>| self-reliant | 1 | 2 | 3 | 4 | 5 | 6 | 7 | makes decisions easily | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| yielding (giving up) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | compassionate | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| helpful | 1 | 2 | 3 | 4 | 5 | 6 | 7 | sincere | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| defends own beliefs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | self-sufficient | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| cheerful | 1 | 2 | 3 | 4 | 5 | 6 | 7 | eager to soothe hurt feelings | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| moody | 1 | 2 | 3 | 4 | 5 | 6 | 7 | conceited | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| independent | 1 | 2 | 3 | 4 | 5 | 6 | 7 | dominant | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| shy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | soft spoken | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| conscientious | 1 | 2 | 3 | 4 | 5 | 6 | 7 | likable | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| athletic | 1 | 2 | 3 | 4 | 5 | 6 | 7 | masculine | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| affectionate | 1 | 2 | 3 | 4 | 5 | 6 | 7 | warm | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| theatrical | 1 | 2 | 3 | 4 | 5 | 6 | 7 | solemn | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| assertive | 1 | 2 | 3 | 4 | 5 | 6 | 7 | willing to take a stand | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| flatterable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | tender | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| happy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | friendly | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| strong personality | 1 | 2 | 3 | 4 | 5 | 6 | 7 | aggressive | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| loyal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | gullible | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| unpredictable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | inefficient | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| forceful | 1 | 2 | 3 | 4 | 5 | 6 | 7 | acts as a leader | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| feminine | 1 | 2 | 3 | 4 | 5 | 6 | 7 | childlike | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| reliable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | adaptable | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| analytical | 1 | 2 | 3 | 4 | 5 | 6 | 7 | individualistic | 1 | 2 | 3 | 4 | 5 | 6 | 7 |</p>
<table>
<thead>
<tr>
<th>Term</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>sympathetic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>does not use harsh language</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>jealous</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>unsystematic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>has leadership abilities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>competitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sensitive to the needs of</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loves children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>truthful</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>tactful</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>willing to take risks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>ambitious</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>understanding</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>gentle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>secretive</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>conventional</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES


BIOGRAPHICAL SKETCH

I was born in Tolbuhin (Dobrich), Bulgaria, in 1978. After our migration in 1989, I completed my secondary education in Turkey. I earned bachelor’s degree in chemistry education from Middle East Technical University (METU) in Ankara. I enrolled in the secondary science and mathematics education master’s program at the same university. In the meanwhile, I was awarded the Council of Higher Education scholarship for pursuing Ph.D. in science education at Florida State University in the US, and started my doctoral program in 2001.

After earning my bachelor’s degree, I taught chemistry at Bilim College as intern teacher and English at Dr. Rıdvan-Binnaz Ege Anatolian High School, both in Ankara. I tutored science and mathematics courses to numerous students at secondary level. I also had a summer internship in a leading glassware company as a chemist during my undergraduate education. Covering the two realms of science and education, these professional experiences, I believe, enhanced my teaching and research skills, as well as content knowledge, in both.

As I complete my doctorate, I look forward to teaching chemistry/science education at the university level and doing research in my field. In specific, I am eager to work on projects targeting gender equity in Turkey and other contexts.