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Doing Science: Lessons Learned from the Oral Histories of

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Abstract

The major purpose of this study was to examine, through the use of oral history technique, the lived experiences of seven women scientists and the factors that affected their pursuit of science. Numerous reports indicate that while women are gaining ground in the sciences, they are behind their male counterparts in many areas and continue to face barriers (National Science Foundation Report, 2002; Wilson, 2004). There is still work to be done to understand how gender differences in science participation affect the lives of women scientists (Clewell and Campbell, 2002). The qualitative data from seven women’s histories was coded to identify emerging themes in the areas of family life, education and experiences with science. The seven women interviewed represented work in science, technology, engineering and math, had terminal degrees and 10 to 55 years of professional experience.

Six themes were identified as major factors in the science careers of these women; experiences with science, support from others, an ethic of care, passions of the mind, self efficacy in science and belonging vs. marginality. Each of these had some impact on each woman’s sense of identity as a scientist and their strong sense of agency for accomplishing their career goals. The factors and influences that lead them to their careers speak to the ways in which they were able to overcome any barriers and become successful scientists.

The stories of these women present a picture that is both consistent with and offers some challenge to the feminist critique of science. While their stories attest to the predominance of males in science they also refute that image in the way these women
were able to create a science career for themselves that is not solely defined by the conditions of a male science. As the feminist critique suggests, gender is an important variable in the factors influencing the pursuit of science. While these women acknowledged the role of gender in their scientific experience they often saw it as outside themselves. This study offers some assertions that might be considered for further research into how women can successfully pursue science careers.
A woman who has a head full of Greek like Madame Dacier or one who engages in debate about the intricacies of mechanics like Marquise du Chatelet, might just as well have a beard, for that expresses in more recognizable form the profundity for which she strives.

Kant as quoted in Schiebinger, 1989
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CHAPTER 1

Statement of Problem

Women’s Participation in Science

While women have made significant strides in the rate of participation in scientific fields, they are still woefully behind their male counterparts in many areas (Clewell and Campbell, 2002; Kahle and Meece, 1994; National Science Foundation Report, 2002; Tobias, 1994; Wilson, 2004). Women are still underrepresented in physical science, engineering, computer science, and math. For example, according to a report by the National Council for Research on Women, 84% of computer science degrees were awarded to women in 1984, but in 1999 that had fallen to 20% (Nobles, 2002). They are less likely to expect to earn a doctorate and changes in the number of women in the science and engineering workforce (in spite of increase college enrollments in some areas) are stagnant or declining. In the life sciences, 50% of doctorates have gone to women, while in the physical sciences 29% of doctorates were women; in engineering the rate drops to 19% (National Science Foundation Report, 2002). For a selected group of Research I institutions, the percentage of women who receive doctorates is much higher (nearly double in some cases) than the percentage of women who teach at those institutions indicating women are not s likely to receive the academic appointments once they have the doctorate (Wilson, 2004). About 26% of the workforce with doctorates in science or engineering are women and fewer than 10% of tenured faculty members in math are female (Monastersky, 2005).
In particular, women still struggle to find equality with their male colleagues in academia. Women find research universities uncomfortable and often hostile environments where they cannot progress as fast as men (Lazarus, Ritter and Ambrose, 2001; Rosser, 2000b; Wilson, 2004). Furthermore, young female scholars often get the message that having children and a career in scientific professions don’t mix. While the numbers of women may have increased in some disciplines of science, many have argued that women still do not participate equally in science, often working at the margins of the scientific profession and lagging behind men in tenure and promotion in academia (Eisenhart and Finkel, 1998; Harding, 1998b; Jacobs, 1995; Rosser, 2000b; Wilson, 2004). Lazarus, et.al. (2002) suggest in their book on women in academia, that doctoral programs are still full of stereotypes and barriers and that women have to be aggressive and politically astute to survive in a predominantly male graduate school environment. They suggest there are all kinds of “little ways” the system does not work for women: male students excluding female colleagues from informal lunch gatherings where insider information is shared, the lack of female role models and conflicts with family life (Bozeman, 2004) to name a few.

There continues to be concern about how to get more women into science fields. A recent report by the National Science Foundation (2003) continues the call for more women and minorities in the science and engineering workforce as one way to resolve the current and ongoing shortages in these areas. The prevailing image of science is still that of a white male project (Bodkzin and Geringer, 2001; Chambers, 1983; Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (CAWMSET), 2000; Parsons, 1997). It is clear there is still
work to be done to understand why women continue to fall behind their male counterparts in many aspects of the science profession especially in academia (Clewell and Campbell, 2002; Wilson, 2004). Clewell and Campbell (2002), after tracking indicators of women’s progress in science, conclude that gender remains a predictor of success in science and that true parity is yet to be achieved in the profession.

The question of women’s participation in science was recently thrown into the spotlight by the comments of Harvard University President, Dr. Lawrence Summers. At a professional meeting he offered some controversial reasons for the under-representation of women (Summers, 2005). He suggested that one reason might be that women with children are not willing to work the required 80 hour work week expected of scientists. Secondly, he suggested that genetics or some innate inability may explain why girls do not score as well as boys in math and science tests in late high school years. The response to Dr. Summers comments have been numerous and forceful and most importantly have raised the level of the discussion around this question of why there are not more women in some science fields. His remarks and the resulting firestorm they created are an indication of the complexity of this issue and the need for greater understanding of the issues women face in pursuing science professions. Some have argued that Summers’ remarks are consistent with stereotypes about women in science and that by propagating those stereotypes he contributed to the notion that women cannot do science (Monastersky, 2005). A significant component of the responses has been to highlight the number of barriers women face in pursuing math and science profession. Dr. Silverburg (as quoted in Monastersky, 2005) a professor of math and computer science suggested that there would be few male mathematicians as well if they had to
face the same prejudice and discrimination as women. The numerous responses to Summers’ remarks (WISELI, 2005), including his own remarks of apology (Summers, 2005) have increased the awareness of the very real barriers women face in pursuing science in academia. Knowing in fact that women do practice science leads to the question of how they negotiate these barriers to do so.

While women are usually a minority in any given science profession, women do practice science in industry and academia. The existence of these successful women scientists begs several questions.

- What were the significant areas of influence that supported and encouraged these women to become scientists?
- What barriers did these women encounter and how did they overcome those barriers to participate in this field?
- How did they negotiate their own social situation to enter a field that would seem to relegate them to the margins of its experience?
- What were the significant factors of influence that maintained their interest in science?
- Where did they find support to persist in their science careers?

This study proposed that the answers to these questions could be found through an understanding of the lived experience of contemporary women scientists.

**Purpose of the Study**

The purpose of this study was to capture, through oral histories of contemporary women scientists, the significant experiences that influenced their pursuit of scientific careers. The study looked specifically at how family, education, and experiences with
science affected the occupational decisions and scientific work of the women interviewed in the study. Science in this study included disciplines in science, technology, engineering and math (STEM) fields. This was an interpretive project that sought to examine the lived experience of women scientists and critiqued the accessibility of science for women; examine the role of gender in pursuing a science profession; relate the lived experiences of women scientists to the feminist critique of science; and offer insight into the ways in which women scientists have successfully overcome barriers and stereotypes. It was a qualitative inquiry using constructivist grounded theory as its framework. Its central feature was to develop the inquiry (through the use of oral history technique) from the standpoint of those who lived the experience. Charmaz (2000) described constructivist grounded theory as a re-visioning of grounded theory that addresses post-positivist criticism about objectifying experience. This study sought to develop possible theories, presented as assertions, about how women succeed in science based on their own stories without imposing an assumption that there are specific ways of defining that success. It relied on the narrative of lived experience to present possible ways in which science is and can be more accessible to women.

**Approach**

Because this narrative of lived experience was central to this study, it was important that the method provide a way to give voice to the woman scientists who were being studied. The way people speak of themselves, their experiences and the connections they make is significant and reveals the way they see themselves and the world in which they live (Gilligan, 1982). Oral history provides for the type of data collection that achieves that voice as well as the interpretative structure that finds
meaning behind the experience. Conducting oral histories in the framework of constructivist grounded theory allowed the researcher to “paint” a picture of the experience of women scientists that draws from, reassembles and renders their experience. It underscored the way in which ideas and experience are re-created in an evolving process (Connelly and Clandinin, 1990). The fact that constructivist grounded theory recognizes the interactive nature of data collection and analysis (Charmaz, 2000) means that interpretation and interaction with the data can be ongoing and can inform the interviews themselves as opposed to creating a data set that is analyzed once all data is collected. In this way, data collection is contextual and self correcting. Oral history requires awareness of the presence of the researcher in doing the interviews and interpreting the experience (Anderson and Jack, 1991). This role is central to the framework of constructivist grounded theory. While the woman scientist in this study was the source of the experience and its context, the analysis by the researcher provided an opportunity to paint a picture of the women’s collective and individual experience. While this picture was based on the individual recollections, it also reflected the input of the researcher as interpreter. Acknowledging this dynamic is central to both oral history method and constructivist grounded theory.

Oral history has become popular among feminists as a way to bring forth women’s experience in a culture that traditionally relies on masculine interpretation (Anderson and Jack, 1991). This made it especially relevant to understanding the experiences of women in a male dominated field like science. Oral histories are very relevant to understanding women’s history and experience but should be done from a feminist perspective to reach this goal (Minister, 1991). Minister argues that the
researcher must be mindful of the approach of the interview and the way in which the researcher can allow for the voice of the narrator. For example, women often approach communication from the perspective of who they are rather than what they do. Furthermore, oral history for women, when it is done between two women, provides a context for constructing and understanding cultural identity that is not found in any shared history at the institutional level, as is the case for men.

Oral history in its own right not a specific feminist project, but putting it in the context of constructivist grounded theory can make it one. This is true because this framework allows for the voice of the narrator and acknowledges the presence of the researcher and the impact of the process on retelling the story of the woman’s lived experience. It allows for what Anderson and Jack (1991) call the “dynamic unfolding of the subject’s point of view” by attending to “the presence of the absence” and makes this central to the ongoing analysis and goal of the research. The “presence of the absence” refers to the way in which women’s experiences can be buried in the norms and roles that are supposed to define them. This study assumed that this is especially true for women in science and suggested that a feminist framework is not only consistent with the purpose of the study but required to achieve its goals.

*Women’s Stories: Exemplars of Experience*

Central to this project was the belief that women’s stories can be instructive about the ways in which women can and do become scientists. As exemplars of experience, practicing scientists can lead reform in science and science education through direct action or as examples of experience, i.e. sharing their stories. Women scientists like Ruth
Bleier¹, Evelyn Fox Keller², Donna Haraway³, Ruth Hubbard⁴ and Linda Shepherd⁵, who have become active in the discussion and research on women in science, are good examples of the role practicing women scientists can play. Through action and example, they offer a perspective from inside the world of science that includes their own lived experiences as scientist’s negotiating the central place of gender in their own work.

Likewise science historians have made the case for how important it is to document and share the stories of women in the history of science. This is poorly documented at best and that lack of documentation has contributed to the perception that women do not practice science, or at least don’t do it well. Women who have led this approach to reform in science include Margaret Rossiter (1982), Londa Schiebinger (1989), and Sue Rosser (2000). As far back as 1405, Christine de Pizan offered a template for documenting the contributions of women in the arts and sciences in her book *The City of Ladies*. While her story is allegorical, her dual aim was to refute the misogynist vision of women as sinful (not only less than man, but a threat to him), and to instill in women readers a sense of self worth they might not find in their ordinary experience. The pictures she paints of “illustrious heroines” are powerful in their ability to create the possibility that women can be artists and inventors and the builders of cities. Centuries later, Evelyn Fox Keller’s biography of Barbara McClintock (1983) presents a

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¹ Ruth Bleier was medical doctor who was dedicated to disproving the myth that many gender differences in the areas of math, verbal skills and creativity are biologically based. She argued that those differences are a result of social and political forces.
² Trained in Physics, Evelyn Fox-Keller’s research focuses on the history and philosophy of modern biology and on the interplay of gender and science.
³ Haraway was trained as biologist, but has written extensively on the history and philosophy of science, examining metaphors of science and the politics of science and technology.
⁴ Hubbard has written extensively on the technical, philosophical, and sociological aspects of biology specifically critiquing the biological theory of women’s equality.
⁵ Shepherd draws on her personal experience as a biochemist and the experiences of other women scientists to write about the value of feminine qualities in the process of science.
real life example of how women have contributed to science and the struggle they encounter in making and being recognized for that contribution. There are other women whose lives as scientists can be powerful examples such as Hildegard of Bingen\(^6\), Hypatia\(^7\), Evelyn Swallow Richards\(^8\), Rosalind Franklin\(^9\), Caroline Herschel\(^10\), Rachel Carson\(^11\), Laura Bassi\(^12\), and Dorothy Exelbren\(^13\) and the woman every student of science has heard about – Marie Curie. Each of these stories includes elements of what it takes for women to pursue and practice science, particularly in their own historical moment. Moreover, they attest to the fact that there have been successful women scientists throughout history and that pursuing that profession has always presented barriers to women. Their lives are examples of how those barriers may or may not be overcome. Indeed reading about successful women can be seen as a form of mentoring for other women (Waltman, 2004).

Contemporary women scientists also have powerful stories to tell of their experiences in science and can be the best and most current exemplars one can find. Linda Shepherd offers stories of numerous women scientist in her book *Lifting the Veil*, which discusses the way women practice science from their own social locations. While many have offered critiques of science and why it is exclusionary of women, those who have successfully become scientists can offer their own lived experience as exemplars of

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\(^6\) Bingen was an 11th century mystic who wrote extensively on natural history.

\(^7\) Hypatia was a mathematician, astronomer, and Platonic philosopher.

\(^8\) Richards was a chemist who is credited with creating the study of home economics based in her chemistry training.

\(^9\) Franklin worked closely with Watson and Crick in the discovery of the double helix but was not given the same level of credit they received including the Nobel Prize.

\(^10\) Herschel was an 18\(^{th}\) century astronomer who worked as her brother’s assistant but was eventually credited with the discovery of 8 comets.

\(^11\) Carson exposed the dangers of DDT in her famous book *Silent Spring*.

\(^12\) Bassi was an 18\(^{th}\) century physicist and the first women to occupy a chair of physics at a university.

\(^13\) Exelbren, Germany’s first medical doctor, dealt with resistance to women studying science and in 1742 wrote a book titled *Inquiry into the Causes Preventing the Female Sex from Studying*. 

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how that critique plays out in practicing science and how they have negotiated the various obstacles, barriers and opportunities in becoming women scientists. They can present a picture of what it is like to practice science as a woman and to what extent they did or did not feel marginalized. Recent articles in popular publications like *Scientific American* and *The New York Times*, have given a glimpse of a few of these contemporary women including Lynn Margulis, Jody Deming, Ruth Patrick, Linda Bartoshuk and Jill Tarter. These stories tell of the elements that come together in creating a successful women scientist; personal experiences with science, significant others, systems of support and internal motivations and desires. However, the rest of the numerous women practicing science in universities, labs, hospital and other organizations should not be overlooked as exemplars and most likely have powerful and educational stories to tell as well. Moreover, their own social and cultural context adds meaning to the significance of their stories.

*Rationale and Usefulness*

This study proposed that contemporary women scientists can serve as exemplars of experience and in doing so can provide insight into the ways in which women are able to access careers in science. It suggested that lived experience can be an instructive and powerful way to understand the complex issues facing women pursuing a science career. Knowledge gained through these oral histories was used to examine the ways in which

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14 Margulis is a contemporary scientist who is best known for her theory of symbiogenesis, which challenges a central tenet of neodarwinism.
15 Deming has received recognition for her study of cold-adapted bacteria and how they offer valuable insights into the origins of life on Earth.
16 Patrick is a pioneer in the field of limnology and responsible for raising serious ecological concerns about water quality.
17 Bartoshuk is a Yale University surgeon who has received acclaim for her work on genetic variation in taste perception.
18 Tartar is an astronomer and director of Project Phoenix, Search for Extraterrestrial Intelligence.
women have chosen and pursued scientific careers – what interests and desires motivated their pursuit, what experiences supported them in their education and work, what barriers they faced and how were these overcome, and to what extent did they feel marginalized in their experience. It considered the influence of gender in the pursuit of a science career and examined the extent to which lived experience of female scientists is consistent with elements of the feminist critique of science (Creager, Lunbeck and Schiebinger, 2001; Haraway, 1988; Harding, 1986, 1991; Keller, 1985; 2001,). From this analysis, useful information might be gained about ways to increase the diversity of practicing scientists as well as the ways in which women’s participation in science affects the image of science (Shepherd, 1993) and scientific research (Fedigan, 2001). Examples of successful women scientists can also be used to challenge the image of science as a primarily white male pursuit (CAWMSET, 2000; Klienman, 1998).

The lived experiences of women scientists can inform students and teachers about the way in which science is influenced by society and culture as well as the role gender plays in who participates in scientific pursuits (Barton, 1997; Rosser, 2000). In this way, the study can validate the importance of educational and societal initiatives to increase the diversity of women scientists by showing how their own pursuit included similar experiences. These initiatives include feminist pedagogy and educational reform, government programs and funding, and revised science standards (Clewell and Campbell, 2002). Additionally, this study considered whether a theory can be developed that relates the experiences of women in science to the importance of teaching the social context/nature of science. The social context of science is central to the feminist critique of science and the particular ways in which women have been excluded from the practice
of science through the interplay of gender roles and the image of science (Clewell and Campbell, 2002; Eisenhart and Finkel, 1998). The social nature of science has been included in the national science standards (National Science Teachers Association, 1998) but whether it has been explicitly connected to the issues of gender and the success of women in science can be questioned. Much has been written about gender and science, but there still seem to be central questions about why more women are not involved in certain science fields. As Clewell and Campbell (2002) conclude in their review of the progress of women in science and engineering,

> Although there are a variety of hypotheses as to why gender differences in interest in different science areas exist (e.g. parental and teacher stereotypes, media representation, even the appearance and actions of scientists themselves) little research has been done in this area. (p.270)

This study suggested that understanding the lives of women scientists and the various ways in which they came to their professions is a fundamental component of this needed research. Additionally, these women exemplars show how it is possible to be as Clewell and Campbell suggest “comfortable participants in the world of science and engineering” (p.278).

A common theme that emerges from the stories of successful women scientists (Keller, 1983; Rosser, 2000; Rossiter, 1982; Schiebinger, 1989; Shepherd, 1993;) is the strong sense of agency. In *Women’s Ways of Knowing* (Belenky, Clinchy, Goldberger and Tarule, 1986), the authors posit that women have a different way of coming to knowledge and understanding than men. Women are more prone to be connected knowers and gain access to information and knowledge through other’s experiences. Whether gender differences in cognitive areas are based in biology or come from an interaction of social factors and biology (Gilligan, 1982), this idea may be significant in
the way women approach science learning as well as their ability to develop a sense of agency about a field in which they would be a minority. In the following, Belenky and her colleagues (1986) attribute an emergent sense of agency with an interior voice;

Along with a sense of personal authority arises a sense of voice – in its earliest form, a still small voice to which a woman begins to attend rather than the long familiar external voices that have directed her life. This interior voice has become for us, the hallmark of women’s emergent sense of agency and control.” (p.68)

Perhaps the stories of others experience is a source for that internal voice, creating a vision that women can be scientists and fueling the agency a young woman needs to get there.

Constructivist grounded theory shows how qualitative research produces more than just descriptive data. In the end, the researcher presents descriptions of how the narrator defines their own reality in the context of their experience. These descriptions include the way variables such as gender, education, scientific experience, and family life have attained meaning in the woman’s life as a scientist. It also acknowledges the role of the researcher in interpreting and telling the story (Tierney, 2000). It does not result in a generalized truth for all, but rather new questions and hypotheses for further study. Hopefully, it also provides significant challenges to the image of who does science as well as models of experience that describe how women negotiate gender and science to pursue their careers.

The experiences of the seven women scientists interviewed for this study help to paint a picture of what might be consider an “ideal type” of woman who pursues science. This ideal is not meant to be exclusive of others, but rather to highlight the factors and influences that supported the pursuit of science for these women. While each woman
presented her own individual story, in the analysis of these oral histories as a group several themes emerged that helped construct this ideal type and offer insights into ways that women can overcome barriers to pursuing science. It was clear that each woman had developed her own science identity and had a strong sense of agency about her ability to be a scientist. This identity and agency sprang from a strong sense of self, a passion for scientific study and a sense of calling to use their special talents in science. These were supported by a number of life experiences from an early age including formal and informal science experiences the support of family and others.

Limitations of the Study

This study looks specifically at the interplay of gender and science. It does not consider race, ethnicity, sexual orientation, socio-economic status or other social or cultural definitions of identity. These certainly can be considered as factors in who pursues science, how the projects of science are determined and how science identity is defined (Harding, 1998a). The participants in this study did not represent a sample of the population of scientists in terms of these variables. Furthermore, these participants are primarily academic scientists and may not represent the experience of women who work exclusively in industry, health care, government or other areas of scientific research and practice.
CHAPTER 2

Literature Review

Feminist Critique - Science as Socially Situated

Feminist scholars who have critiqued science represent many disciplines including the work of philosophers of science (Harding, 1991, 1998), science historians (Rossiter, 1982; Schiebinger, 1987, 1989, 2002) women’s studies scholars (Rosser, 1990, 1991, 2000) educators (Kahle, et.al., 1993; Klienman, 1998; Mies, 1990; O’Dea, 1997), anthropologists (Eisenhart and Finkel, 1998; Traweek, 1988;) and female scientists, (Bleier, 1986; Haraway, 1988; Keller, 1985; Spanier, 1986; Shephard, 1993), to name a few. In their review of the literature, Wylie, Okriukik, Theilen-Wison, and Martin (1989) cited an enormous range of literature on the subject and pointed to two main sources of inspiration for the project; the first from those within the sciences responding to androcentric practice and the second from feminist theorists analyzing patriarchal forces in society. In her book “The Science Question in Feminism (1986), Harding identified 5 different themes or projects in the feminist critique. These are:

- the inequities of female representation in the sciences,
- the use and abuse of science to support social projects,
- how research problems/questions are chosen,
- the use of language and metaphor that have been handed down by the “fathers” of modern science
- the question of how knowledge is defined and how this related to the social experiences.

Each of these points to a fundamental belief in the feminist critique that says science is practiced in the context of social and cultural forces. In this way, gender becomes a central issue in the practice of science. Additionally, the feminist critique challenges the value free, unbiased notion of objectivity in science and proposes an alternate “strong” or
“dynamic” objectivity (Keller, 1985; Harding, 1991) that acknowledges the social nature of science and its projects. The groundwork for this was laid by Kuhn (1970) in his book The Structure of Scientific Revolutions. This work is cited by numerous feminist writers who critique the practice of science.

While other social influences are important (i.e. race and ethnicity) much of the critique focuses on the male/female dichotomy. Much has been written in the last three decades on the “male” nature of science and Kleinman (1998) concludes that science has an underlying ideology that can still be interpreted as masculine. She expresses this succinctly in saying “…masculine ideology is so entrenched it has become transparent” (p.843). The role of gender has not only been significant in the history of science but also in the way scientific knowledge is perceived as well as the various projects of science (Bleier, 1986; Haraway, 1988; Harding; 1986; Keller, 1985; Merchant, 1980; Rosser, 1990). From the writings of Keller, Harding, Haraway and others, the masculine nature of science is illuminated in its approach to objectivity, the type of questions it asks, its methodology and its relationship to nature. For several critics, the androcentric nature of science is played out in exercises of power, control and domination. According to Sandra Harding (1991), science is a self identified regime that bears the imprint of those who define it. In its construction as a male enterprise, women are left out of that definition, both in terms of what knowledge is, how it is presented and what the projects of science ought to be.

According to many authors the social construction of gender is central to the way science is practiced and who should engage in that practice (Harding, 1991; Keller, 1985; Rosser, 1990; Schiebinger, 1989). What it means to be a woman and what it means to be
a scientist in our society are often at odds. As Harding (1991) says about who is most likely to be a scientist:

…the very same personality traits that young males must take on to become masculine in the modern West are just those that are particularly valued for careers in science and related fields. Facility in abstract thought, physical interaction with the environment, and a conception of nature as separate and in need of control— which parents and society encourage in male children in order to make them more manly— are just what prepares young people to like and excel at math, science and engineering. Correlatively, in order to make female children more feminine and womanly, parents encourage a tendency toward concrete and relational thought and a preference for personal, caring service to other people. These traits prepare girls and women to prefer teaching, mothering and other service and caring activities to those that are essential for careers in mathematics, science and engineering. (p.28-29)

This quote embodies many of the social and cultural variables that might influence a person’s decision to be a scientist and the way that scientific experience will be defined. The feminist critique offers several challenges to the way gender has defined science and its participants. While these critiques vary depending on the feminist theory from which they arise, some common themes point to the types of fundamental ways in which science has excluded women and ways in which that exclusion has limited the scope of science. Working as a mathematical biophysicist, Evelyn Fox-Keller began to question the male perspective of the field in which she was she was immersed.

According to Keller (1983),

Every scientist comes to his subject with worldview that is uniquely his own— a world view that is reflected in his relation to people as to his subject. Each brings a distinct set of interests— interests stamped by his or her own personality. (p. 49-50)

In her book Reflections on Gender and Science, Keller (1985) reviews of the development of scientific thought and challenges the masculine ideology that developed from the writings of men like Bacon and Plato. Keller’s writing embodies several
elements of the critique including the relationship of the researcher to his or her subject, the nature of objectivity and the social context of science. In addition to those elements, the critique centers on science’s relation to nature, the use of dichotomies that present truth as an either/or proposition, the lack of focus on the connections and interrelationship, a separation from lived reality and limitation of how knowledge is defined. Nearly two decades before Keller’s book, Kuhn (1970) had written about the paradigms of science and the way they are influenced by political and social forces. From this work Keller found support for the proposition that scientific neutrality is not all that neutral. It cannot be separated from the political and social forces of the day. In this context, she demonstrates how scientific knowledge has developed under the forces of patriarchy and male history.

_Feminist Standpoint Theory: Gender and the Male Nature of Science_  
In the context of science as knowledge, the feminist critique offers three alternate epistemological programs; feminist empiricism, feminist standpoint theory and feminist postmodernism (Harding, 1986). Again, gender is a central theme. Feminist empiricism accepts the traditional norms and philosophy of science and focuses on the issues of women’s roles within the sciences while ignoring deeper issues such as gender bias in the nature of science. It does not propose deviance from scientific norms but argues for greater participation by women in the context of science as it is. Feminist standpoint focuses on the experiential aspect of science and argues that science knowledge is socially situated. This means that social and cultural variables affect the projects of science as well as stratify participation based on gender, class and race. Since women’s roles in science have been limited, scientific knowledge is incomplete; the predominantly
male perspective offers a partial view of science knowledge and its projects. Feminist postmodernism reacts specifically to the high value placed on scientific rationality. It does not give specific attention to issues of gender in science and for this reason receives little attention from some feminists in envisioning a more feminist science (Harding, 1991; Roychoudhury, Tippins and Nichols, 1995). The existence of these alternate approaches reveals the different directions the critique has taken as well as the challenge this critique presents to the epistemology of traditional science. However, feminist standpoint theory provides the greatest focus on the impact of the male nature of science in the way it focuses on personal, social and cultural variables affect participation in science and its approach to objectivity.

Consistent with standpoint theory, Keller’s proposition that every scientist approaches the subject from his or her own worldview points to the social nature of science and its centrality in the feminist critique (Bleier, 1986; Haraway, 1988; Harding, 1986; Keller, 1985; Klienman, 1998; Longino, 2002; Rosser, 1990). Harding (1986) claims that science mirrors social structures such the division of labor and the control of social policy through the questions it asks. Many authors write about the exclusion of women from medical research as subjects and the way this impacts health policy (Bleier, 1986; Rosser, 1990). Rosser (1990) points out that primate research was initially guided by the assumption that social structures in animals reflect the male perspective on social structure in humans. Dian Fosey and other primatologists demonstrated a new understanding of primate social behavior by offering alternate ways of viewing social structure. Other critiques (Kleinman, 1998; Rosser, 1990) point to the uses of science for military and other patriotic national agendas that are less appealing to women as a whole.
These uses not only turn women away from science but can be shown as ways in which science has been used to promote sexist, racist and classist agendas (Harding, 1991). In the context of the scientific method, science would seem to have protected itself from such social bias. Feminist standpoint theory disputes pure objectivity in science by connecting the socially mediated roles with access to the scientific enterprise. Harding (1989) says that feminist standpoint theory

“..eschews blind allegiance to scientific method observing that no method, at least in the sciences sense of the term, is powerful enough to eliminate the kinds of social bias that are as widely held as in the scientific community” (p. 196).

Acknowledging the social context of science can be a way to affirm the significance of scientific knowledge as opposed to refuting it. If rationality is central to the scientific method, it does not have to be viewed as mutually exclusive from social influences. Longino (2002) discusses the possibilities of a more inclusive science when the rational-social dichotomy is removed from the analysis. Rational approaches in science can be context dependent and still lead to “good science.” This is likely closer to the way knowledge is actually created in science than what is described by the rational perspective that does not acknowledge or seeks to negate social influence.

Social context; Objectivity and Identity

Standpoint theory critiques how the male nature of science approaches the underlying concepts of objectivity and rationality, a key element of the scientific method (Bleier, 1986; Haraway, 1988; Harding, 1991; Keller, 1985). The underlying assumption is that hypothesis, research and conclusions are drawn from an objective, value-free perspective. The feminist critique would argue that this is not possible and that indeed the method of science has been affected by the personal histories and experiences of the
scientists themselves. This is not necessarily wrong, but should be acknowledged. For feminists it creates problems for scientists in that so many perspectives are left out of the community of researchers, particularly based on gender, but also class and race. Harding (1991) calls for the notion of “strong objectivity”, in which standards are given for critically examining the many aspects of scientific evidence that now go unexamined, primarily because they are overlooked or dismissed in the male paradigm.

                     Feminism needs sciences that are more objective than the knowledge-seeking practices of androcentric, bourgeois groups in the West which have been passed off as an objective, dispassionate, disinterested, universal science. Women- and men- cannot understand or explain the world we live in or the real choices we have as long as the sciences describe and explain the world primarily from the perspectives on the lives of the dominant groups. (p.307)

Not only does this traditional scientific notion of objectivity call into question the way science defines our world, it also makes an appeal to certain types of people to be practicing scientists. Science has a way of creating its own “social person” (who does science best) as one who fits the cultural definition of male (Harding, 1991; Keller, 1985). Keller (1986) lists scientific personality traits as loners with low social interests, low sex drives and high “masculinity”. Of course not all scientists fit these descriptions, but the culture of science creates stereotypes about who is supposed to “do science” (Brickhouse, Lowery and Schultz, 2000). Keller (1985) also argues that at a very young age, children make connections about the relationship of masculinity and femininity and autonomy. It is through these connections that interests and comforts develop in certain areas. While, this disconnected, dispassionate, autonomous nature of science fits more closely with the construction of masculinity, many would take issue with the fact that this is the way science is most effectively practiced.
A major aspect of objectivity that feminist critique takes issue with is the underlying assumption of autonomy and disconnection. Keller (1985) makes a distinction between static objectivity and dynamic objectivity. Static objectivity separates the object from the subject a practice seemingly inherent to traditional scientific method. In doing so, it precludes seeing any connections between the two and the impact of the subjective experience. Dynamic objectivity on the other hand, begins with the principles of connections and relationships, yet keeps in tact independent integrity by recognizing differences between self and other. It requires a science that recognizes both difference and continuity and seeks connections as part of the pursuit of knowledge. In the context of feminist empiricism, this expanded notion of objectivity enters the dominant discourse of traditional science in a way that creates less resistance from traditional science (Harding, 1991).

However, the feminist question of objectivity, including Keller’s notion of dynamic objectivity goes beyond revisions of scientific method as usual. It challenges the fundamental concept of value neutrality and recognizes that historically, politically and socially, objectivity in science has never been value neutral (Harding, 1991). It also calls for a fundamental change in the approach of science that incorporates the experience/perspective of the subject and acknowledges what Haraway (1988) calls the privilege of partial perspective. The false presumption of value neutrality overlooks the dominant voices that have defined knowledge in science and those that this discourse has silenced and ignored. Harstock (1983) describes the standpoint theory of knowledge that recognizes the dominance of certain ideologies in defining what is real and true. In applying feminist standpoint theory to science one must acknowledge the voices of those
silenced based on gender as well as race and class. She presents one of the fundamental ways in which the female voice is silenced in the relationship between gender construction and the definition of scientific knowledge. While the male bias of science presents scientific knowledge in the context of subject versus object,

“the female construction of self in relation to others leads in an opposite direction – toward oppositions to dualism, of any sort, valuation of concrete everyday life, sense of a variety of connectedness and continuities both with other persons and with the natural world.” (Harstock, 1983, p.158)

Women experience themselves and others along a continuum and are not inclined towards the separation of self and other. Gilligan (1982) showed how this is fundamental to the female view of the world and its implications for moral reasoning. The feminist critique of science takes this view into consideration. The social construction of female is not inclined towards static objectivity, but more towards Keller’s dynamic objectivity. Barbara McClintock described this as a way of listening to the subject she was studying and used it successfully in discovering the concept of transposition in genetics (Keller, 1983). However, for a number of years her discovery was disputed because her work was outside the “paradigm” of molecular genetics.19

The feminist standpoint theory challenges the notions of who defines knowledge in science based on its primarily Eurocentric male origins. Harding’s (1996) notion of strong objectivity requires that we deal with these deep-seated biases and allow for the voices of those who have been marginalized. Donna Haraway (1988) describes the feminist version of objectivity as situated knowledge. In this she argues that the only true vision is a partial one, and that we must acknowledge that objectivity will always be

19 McClintock received the 1983 Nobel Prize in physiology or medicine for her discovery of transposition in genes.
limited by location and situated knowledge. In her analysis of the partial perspective, she stresses the importance of the object (of study) as an actor/agent. In doing so she promotes a kind of phenomenology that shifts the focus of the scientific method. Partiality, not universality becomes a condition of knowledge claims and the relationship of the subject to the object becomes an important element of determining “truth”. She stresses the importance of finding truth in connections and webs of relationships. She claims that “objectivity is not about disengagement, but about mutual and usually unequal structuring” (p.595). Haraway argues that we must learn to see from other’s points of view and acknowledge that often the most powerful vision comes not from the powerful but from “below the brilliant space platforms of the powerful” (p.582); in other words the voices of the traditionally oppressed based on race, class and gender (Harstock, 1983; Harding, 1996). Narratives of the lives of woman scientists can offer that perspective from “below” these platforms. They would offer new and perhaps even more objective perspectives on the practice of science.

*Male Science: Controlling Nature and Women*

In addition to science’s relationship to society, the feminist critique focuses on its relationship to nature and equates this with its relationship to gender. The fundamental issue springs from the view one has of the relationship between humanity and nature. Most of the history of science displays a belief that nature is to be named and dominated. Keller (1985) describes the primary object of science as attempting to determine, name and dominate the laws of nature. This focus has its origins in politics and religion (Keller, 1985, Ruether, 1992) in particular, through the prevailing myth that the creation story in the bible presents the earth and nature as an object for the use of humanity. In
fact the bible as well as religious history offers an alternate view that humanity is meant
be in relation with the earth and nature (Clifford, 1992; Merchant, 1980; Ruether, 1992).
Rachel Carson (1971) captured the essence of this domination in her famous book, *Silent
Spring*, on the destruction of the environment through the use of pesticides. The feminist
critique, in a concept called ecofeminism\(^\text{20}\), equates the domination and destruction of
nature with that of patriarchy and the domination of women (Meis, 1990; Merchant,
studying the order of nature. In doing so, she suggests we perceive nature as orderly and
in active participation with the observer. Again the object/subject dichotomy is removed
and the search for truth lies in making connections and “listening to the organism”. As a
woman scientist, McClintock’s example comes up again in acknowledging that nature is
characterized by an a priori complexity that that we cannot understand simply by
imposing our own stories upon it because it most likely exceed the capacity of the human
imagination (Keller, 1985). From McClintock’s work and her own work on slime molds
Keller, concluded that in studying nature we must make a paradigm shift that
encompasses; greater interaction between the knower and what is to be known, a respect
for the gap between theory and phenomenon, and a willingness to relinquish the notion
that the subject can be objectified an absolute truth determined. Gilligan (1982) and
Belenky, et. al. (1997) would suggest that women would bring this new perspective to
science and thus find this consistent with the standpoint theory critique.

\(^{20}\) Ecofeminism is fairly recent development in the feminist movement. It highlights the domination of
capitalism and patriarchy over nature and draws a parallel between the destruction of nature and the
domination of women and others in these systems.
Women’s Scientists and the Nature of Science

The feminist critique makes the distinction between getting more women into science and actually changing the definition of knowledge in science (Scheibinger, 2000). It seems change has occurred in both areas which would be consistent with what some would say is central to the feminist critique, that increasing the participation of women in science will change the nature of science (Rosser, 2000b; Harding, 1998b). It is relevant to note that the way knowledge in science is determined and defined has been questioned from within the science community itself and that in particular post positivism acknowledges the contribution of feminism to this development. While much has been written on the critique much is still to be done and change is called for in many areas including research priorities, epistemology, attitudes in schools, university structures, classroom practice and the relationship between home and life professions (Clewell and Campbell, 2002; Scheibinger, 2000; Wilson, 2004). Clewell and Campbell (2002) discuss the change in women’s participation in science in the context of theories that have developed about gender differences in science participation.

Consistent with the feminist critique there are signs of a paradigm shift within the scientific community (Reuther, 1992). Feminist have noted the way in which discoveries in physics, particularly quantum mechanics, call into question our ability to name everything on our own human terms and thus push for a paradigm shift from within the scientific research community similar to those called for in the feminist critique (Keller, 1985). Indeed the postpositivist movement represents a significant shift in the paradigm of scientific research (Kuhn, 1974). This movement echoes and even draws on many elements of the feminist critique that question the concepts of value neutrality and objectivity that characterize the rational and empirical epistemologies of positivism.
(Philips and Barbules, 2000). This movement lends support to the feminist position that the problem is not with women, but with the production of scientific knowledge itself. Based on Fee (1982) it is not a matter of making women more scientific, but of making science more human and socially conscious. Harding in a recent popular journal (1998b) argued for the contributions women have made to scientific research and practice, notably an improved role in social justice, greater legitimacy in public perception, broadened agendas on health issues, an expanded notion of objectivity and greater care and sensitivity.

On the other hand, liberal feminists would support the notion that science as usual is okay, but that we need to have more women in the field to begin to address some of the gender and bias issues (Harding, 1991; Rosser, 1990; Rossiter, 1982). It is distinct from most other forms in that it supports the traditional notion of science that humans are basically individualistic beings and highly rational, thereby refuting much of the issues around the social construction of science. Most other feminism, such as those based on Marxist ideology, African American culture, socialism, lesbianism and existentialism, take positions that develop from the belief that science is a socially constructed and call into question many of the aspects of traditional science. A fundamental question that arises for all feminists is whether or not there can be a gender free or gender neutral science. Liberal feminists’ belief in the integrity of the scientific method would say yes. Other feminisms that question the value-neutral objectivity at the heart of this process such as standpoint theorists would obviously say no. However, there are other ways of approaching this question that imply the many complexities of the issue. Do these feminist critiques of science simply raise examples of bad science? Is good science
gender free? Does the critique point to better ways of practicing the scientific method, or do they imply that it is inadequate or unacceptable? In 1982, Elizabeth Fee wrote that a sexist science is what we should expect in a sexist society. Imagining a feminist science in our current society is “like asking a medieval peasant to imagine the theory of genetics or the production of a space capsule” (p31). In spite of the presumed limits of that medieval peasant’s imagination, those scientific advances did in fact come to be part of our reality. Regardless of the male bias in science, we have to give credit to science as we know it (male or otherwise) for such accomplishments. At the same time, this story points to the hope that lies in possibilities beyond our imagination. The stories of practicing women scientists provide examples of how that vision can be attained.

**Barriers to Participation**

While standpoint theory focuses on the social nature of science, there is still considerable debate about the reasons for gender differences in science participation. Theories range from innate abilities based on gender to socially mediated attitudes and perceptions. These theories include biological differences that affect achievement in science, social-psychological theories about girls’ perceptions and attitudes towards science, social factors such as teacher attitudes and parent expectations and cognitive explanations about gender differences in learning styles (Clewell and Campbell, 2002). What is significant about these theories is what they suggest about the barriers women still face in getting into science and the many initiatives that have developed to help them overcome these (Clewell and Campbell, 2002; Spears, Dyer, Franks and Montelone, 2004). In spite of these many initiatives, some conclude that too few women have been
resilient enough to overcome the many barriers that still exist (Fadigan and Emmerich, 2004; Wilson, 2004).

Theories about biological differences in science achievement have been discussed and debated widely (Clewell and Campbell, 2002; Monastersky, 2005; WISELI, 2004) and raised valid questions about pedagogy in the science classroom. Whether or not boys and girls have different propensity for understanding and processing scientific knowledge has raised awareness of issues like stereotype threat (Clewell and Campbell, 2002; Monastersky, 2005), classroom climate (Rosser, 1990; Sandler, Silverberg and Hall, 1986), girls perceptions about who can practice science (Brickhouse, 2001; Kleinman, 1998; Rosser, 2000a) and the need for authentic learning in science instruction (Barton, 1997; Roychoudhury, et.al., 1995). Girls often don’t feel like equal participants in the pursuit of knowledge in the science classroom (Rosser, 1992; Sandler, et.al., 1996; Tobias, 1994). One commonly held belief is that girls often feel uncomfortable or intimidated in the science classroom. The construction of identity for girls dictates certain behaviors thus “a girl who is silent in science class may well be acting in this way because she aspires to be a good girl student” (Brickhouse, 2001, p.287). The reason girls don’t engage in science is often attributed to the climate of the science classroom (Rosser, 1990, 2000a; Sandler, et.al., 1986), and the construction of identity (Brickhouse, 2001; Kleinman, 1998). For some students, engaging in science is a way of losing feminine identity (Kleinman, 1998). Others have low self-efficacy in science because they have gotten messages that girls don’t practice science or they can’t excel at something they don’t relate to. Ultimately, the failure of girls to achieve in science can be attributed to the lack of connections they make between who they are (or are supposed
to be), and what science is, or between the study of science and their own lived experience. The propositions that biological differences can be attributed to gender differences in science participation needs to be in light of these issues. Some would argue that the very suggestion that women are at a disadvantage biologically is one of the barriers in the science classroom as was recently highlighted by the controversy over Dr. Summers remarks at Harvard (WISELI, 2004). Heyman, Martyna and Bhatia (2002) found that female engineering students identified engineering aptitude as a fixed ability increasing their tendency to drop classes when faced with a difficulty and were more likely to perceive females as getting different treatment in the classroom from their male counterparts. Bandura, Barbaranelli, Caprara, and Pastorelli, (2001) found that children who perceive themselves as having high academic efficacy perform well academically, have high educational aspirations and feel they are capable of pursuing careers in the sciences. Such studies underscore the importance of belief about abilities as well as the impact of the classroom climate and challenge notions of biological determinism in science achievement.

Another significant area of research on gender-related barriers to participation in science concerns girls’ and women’s perceptions about themselves as scientists. This has been related to the image of who practices science especially since the majority of both female and male students are unlikely to draw pictures of female scientists (Bodzin & Gehringer, 2001; CAWMSET, 2000; Chambers, 1983; Mason and Kahle, 1988; Parsons, 1997). Furthermore, Parsons (1997) concluded that negative stereotypes of scientists and science that begin in the early grades persist throughout high school. Often girls cannot relate science to their own lived experience or daily lives and have difficulty seeing
themselves a scientists (Farmer, Waldrop and Rotella, 1999). Most students do not know what scientists and engineers actually do on a day-to-day basis (Baker and Leary, 1995; Lewis and Collins, 2001). Wyer’s (2003) study of female undergraduate science majors suggested that positive attitudes toward science along with positive perceptions of the images of scientists contributes to one’s persistence in science fields.

Barriers to participation extend beyond pre-college educational experiences (CAWMSET, 2000; Rosser, 2000b; Wilson, 2004). Women who pursue college degrees in science and professional carriers continue to experience resistance and difficulty because they are women. A congressional report on the status of women in science (CAWMSET, 2000) concluded that many barriers still exist for women pursuing science careers. These include the absence of role models, lack of mentoring, exclusion from informal networks, difference in style from white male colleagues and isolation in academics departments. Clewell and Campbell (2002) cite other negative factors for women pursuing science careers including low salaries (especially compared to male counterparts) and the conflicts with career and family goals (Bozeman, 2004). Women seem to have greater difficulty than their male colleagues in accessing science careers especially in academia (Wilson, 2004) and often practice at what some call the margins of the scientific enterprise (Eisenhart and Finkel, 1998). Women who excel in the sciences are still considered anomalies by many (Mannix, 2002). In their book, A Woman’s Guide to Navigating the Ph.D. in Engineering and Science, Lazarus, et. al. (2002) the fields of science and engineering are still laden with numerous stereotypes and hidden barriers. Women have to learn how to negotiate predominantly male graduate
departments that often create environments where female ideas are not welcome, demands of family life are not acknowledged and female role models are lacking.

Influences

Certain cultural variables can be considered central to considering the way in which one’s location and identity in science are defined. These would include family background, educational experiences, religious upbringing and experiences with science. These variables are also significant in the construction of gender. Ross and Rapp (1997) review the ways in which family and kinship, community (i.e. educational institutions) and world systems (i.e. religion) provide the significant contexts for evaluating the construction of gender and sexuality. Several authors have highlighted areas of significant influence for women scientists such as family (Beoku-Betts, 2000; Farenga and Joyce, 1999), parental support (Ethington, 1992; Kahle and Meece, 1994), educational experiences (Barton, 1997; Brickhouse, 2001; Kahle and Meece, 1994; Martin and Brower, 1991; Rosser, 2000; Roychoudhury, et.al., 1995) and role models (Bandura et.al., 2001; Campbell & Beaudry, 1998; Kahle and Meece, 1994; Sadker and Sadker, 1994).

It is evident that several social and cultural factors still exist that discourage girls from participating in science. Kahle and Meece (1994) described four factors that contribute to these differences: individual cognition and attitude, socio-cultural images of science as male, family influences on role expectations and educational experiences, most notably teachers attitude and expectations. These include teachers’ beliefs and attitudes and how this affects girls and boys in the classroom (Arumbula Greenfield, 1997; Kahle, et.al., 1993; Li, 1999) as well as girls beliefs about themselves as scientists (Farenga and
Joyce, 1999). Farenga and Joyce found that gendered images of science began as early as kindergarten. Parents expectations have been found to have a significant effect on the successful pursuit of science careers by girls (Clewell and Campbell, 2002; Ethington, 1992; Farenga and Joyce, 1999). Furthermore the amount and type of informal science experiences also seems to impact the pursuit of science by boys and girls (Farenga, 1995 (in Clewell and Campell, 2002); Lee and Burkham, 1996). Of course, in school experiences are paramount and much has been written about how science is taught and the way this influences the pursuit of science for girls and boys. Science educators have developed pedagogies that incorporate such things as cooperative learning, personal narrative, role models, and situated learning (Barton, 1997; Brickhouse, 2001; Meyer, 1998; Rosser, 1990; Roychoudhury, Nichols and Tippin, 1993). One fundamental aspect of these techniques is to help the student make more connections to the study of science and their own personal experience. Based in part on the writings of Gilligan (1982) and Belenky, et. al. (1986) this is believed to be beneficial not only to girls, but to boys as well.

Some studies have focused on the need to expose more students to the fields of science and engineering and what professionals in these fields actually do (Goodman Research Group, 2002). Use of role models and mentors has been a central feature of feminist pedagogy in science. The Chilly Climate Papers (Sandler, et.al., 1996) stress the importance of incorporating women’s experience into classroom instruction. Richmond, Hoes, Kurth and Hazelwood (1998) developed three themes around feminist pedagogy that arose from their research on specific strategies;

- Helping student rethink connections with science
- Helping students re-envision science
Helping students transform their perspectives into a conception of science they can own

Allowing students to connect with the personal narratives of women scientists would be one approach to rethinking, re-envisioning and transforming. Kleinman (1998) discusses the prevalence of role expectations for women and ways in which this precludes them from careers in science. She points to the fact that women often cannot see themselves in such careers because they lack role models or examples of women who have successfully done so. She cites several studies that have documented the importance of role models for young women scientists and engineers. In particular, physics is an example in which the lack of women physicists makes it difficult to attract more women into the field.

Traweek (1988) describes the way physics is defined by its predominantly male image and recounts her own story of becoming a physicist amidst the stories told in an exclusively male community. The way in which young women form science identities was examined by Brickhouse, et. al. (2000). They discuss the importance of being able to relate to the community of practice. This community is often seen as inaccessible to students for at least two reasons. First, it often appears irrelevant and distant as compared to the lived experience of science students. Second, is the idea that practice as defined by that community falls within a very narrow view. Madill et al. (2000) found that a group of over 100 urban young women enrolled in a science related major were motivated by how the career related to their own lives. The personal narratives of scientists, both male and female could help to alleviate both these concerns. Biographies or autobiographies that focus not only on the specifics of the research but also on the personal struggles and time period in which the scientists lived would be informative and perhaps transformative.
Pedagogy – Changes in Science Education to Attract More Women

Several themes of the feminist critique developed out of the question of how women come to know things (Rosser, 1990). Belenky et al. (1986) as influenced by Gilligan (1982) proposed that there are five perspectives from which women view reality and come to conclusions about truth, knowledge and authority. At the highest level, knowledge is acquired through connected procedural or constructed knowledge. This type of knowledge is acquired through a more holistic view where connection and relationships are essential. This aspect of making connections and working outside of dichotomies and separation from the object have been recurrent themes in the feminist critique of science. Several authors (Brickhouse, 2001; Keller, 1985; Rosser, 1990) argue that women are excluded from scientific study because it is generally not compatible with this way of knowing.

The work of Carol Gilligan (1982) has also provided a foundation for some of the reform in teaching and learning in feminist ideology overall and the critique of science specifically. Her notion of the self in relation to others and the importance of this in the process of moral reasoning and a duty to care has influenced the pedagogy that has developed in the feminist approach to teaching science (Rosser, 1990). The fact that science is often presented as a dispassionate, value-free, fact based field is inconsistent with this notion of women’s approach to the world around them. Several writers discuss ways to incorporate a more caring classroom (Barton, 1997; Rosser, 1990; Sandler, et al., 1996). Based in part on the writings of Gilligan (1982) and Belenky (1986) science educators have developed pedagogies that incorporate such things as cooperative
learning, personal narrative and role models (Brickhouse, 2001; Meyer, 1998; Rosser, 1990). Many science educators have focused on the concept of situated learning in science or putting science in the context of the students’ lived experience (Barton, 1997; Brickhouse et al., 2000; Brickhouse, 2001; Kleinman, 1998; Martin and Brouwer, 1991; Meyer, 1998; Milne, 1998; Richmond et al., 1998; Rosser, 1990; Roychoudhury, et al. 1993; Roychoudhury et al., 1995). One fundamental aspect of these techniques is to help the student make more connections to the study of science and their own personal experience. This is believed to be beneficial not only to girls, but to boys as well. In doing so, it is possible to overcome some of the gender biases of science and help students see relevance to science regardless of their own gender.

The National Association of Women in Education has published a series of papers on what they refer to as the “chilly classroom climate”\(^{21}\). The 1996 edition (Sandler, et al., 1996) looks at the incorporation of women into the classroom in five parts focusing on five different issues. While the document is directed towards education for women in general, its themes are relevant to science instruction specifically. In addressing the classroom climate, the issues that are considered are the following

- how teacher and student behavior creates different expectations for males and females
- the use of collaborative learning and feminist pedagogy
- ways to further integrate women into the curriculum
- impact of teacher style on the evaluation of faculty and students
- broad-based recommendations for administration, faculty and students in ways to make the climate more welcoming to female students.

Several of these themes are not new to the literature and appear in the works of several educators who critique the educational experience for women (Kahle et al., 1993; Rosser, 1990; Milne, 1998).

\(^{21}\) This term is used regularly in the literature in describing the experience most girls have in the classroom in general and the science classroom specifically.
1990). In the context of student and teacher behavior, the authors of the chilly climate papers point to the use of language and the choice of examples as ways women can be included. They specifically point out that this is even more exaggerated in the science classroom and in the constant references to male scientists both in the language of teachers and students and in the text that are used. They conclude that women are not sufficiently incorporated into the curriculum and texts. Additionally, they say that the use of military and other socially destructive uses of science as well as the particular approach to problem solving is not welcoming to female students. Southerland, Newsome and Johnston (2003) found that teachers’ beliefs about the nature of science impacted the way they developed and implemented the science curriculum.

In the section on pedagogy, the Sandler, et.al. (1996) refer to the development of collaborative learning and point to some common themes in the feminist pedagogy. These include neutrality (challenging the value free aspect of science), experience or the use of personal biography, inclusion of students regardless of race, gender or class, non-hierarchical classroom and the importance of empowerment. These themes are repeated in other aspects of the literature on feminist pedagogy and curriculum (Rosser, 1990; Kleinman, 1998). A commonality for these themes is that women simply must be more included in the curriculum. This is from the standpoint of inclusion of women as engaged students (Barton, 1997; Brickhouse, 2000; Martin and Brouwer, 1991) as well as the use of women as examples and role models (Evans, Whigham and Wang, 1995; Milne, 1998; Smith and Erb, 1986; Tobias, 1994; Zacks, 1999). Sandler, et. al. (1996) reinforce what other feminist writers have said both in the context of the critique of
science as well as the critique of the classroom namely that “...the context of education itself validates men even as it invalidates women.” (p.49)

Models of Gender and Science

Kahle, et.al., (1993) developed a model to describe the relationship of gender and science in schools. This model points to the interaction between teacher belief, behavior and attitudes and students belief, behavior and attitude. This Model is shown in Figure 1, Appendix A. Starting with previous experience influenced by culture and society, students and teachers come to science with a certain knowledge, experiences and images. These impact their beliefs and attitudes and ultimately their behaviors. There is an interplay between the students and the teachers that can affect the outcomes for the students in terms of science pursuits. Other studies have cited the impact of teacher beliefs and attitudes on science students especially girls (Jones and Weatley, 1990; Li, 1999). But what is also significant in this model is that students develop behaviors based on their own gender and science experiences and the image they have of science. This can impact self perception, sense of confidence, initiative, involvement and response to learning opportunities. Ultimately, it points to the complexity of the teacher- student relationship in the way gender is negotiated in the classroom and suggests the teacher may be a significant area of influence for girls pursuing science.

Rosser (2000a) proposed a seven stage model of curriculum and pedagogy development to attract a more diverse pool of scientists. Central to this model is the notion that increased diversity in the community of scientists can impact curricular content (what is taught), theoretical underpinnings (the nature of science) and ultimately pedagogical techniques. At the most advanced stages, when the diversity of scientists
approaches the diversity of the population at large (is representative) students can be exposed to the influence of gender and the importance of social context as exemplified in the lives of scientists. Pedagogy requires that students read and critique the lives of practicing scientists to be able to evaluate this social context and view science from the perspective of a diverse group of practitioners. These experiences would reveal the nature of science as a dynamic, connected process as opposed to an objective and disconnected pursuit of information. Examining the lives of practicing women scientists can be applied to the idea of this model.

*Women Practicing Science*

The male image of science is not something new and has affected the role of women in science for decades (Harding, 1991; Rosser, 2000; Rossiter, 1982; Spanier, 1986; Schiebinger, 1989). Historically, many women have practiced science but the documentation of their work is often ambiguous at best. Harding (1991) points out that many women scientists have made significant contributions but, as women, they are kept out of mainstream literature. Historically the male image of science has supported the notion that there are no significant women in the history of science when in fact there have been many (Rosser, 1990; Rossiter, 1982; Scheibinger, 1989). Schiebinger (1989) documents the numerous contributions of women scientists throughout time and the way in which their contributions were either attributed to men or dismissed because they were women. Rossiter (1982) documents the systematic way in which men barred women from the practice of science. Keller’s (1983) biography of Barbara McClintock underscores the way in which the significant contribution of a female scientist can be
overlooked because her work did not fit into the current paradigm of scientific research. Women often occupy “heretical spaces” (Eisenhart and Finkel, 1998) in science such as non-profit organizations where their contributions are more likely noted than in academia (or mainstream, elite science) (Rossiter, 1982). Rosser (1990, 2000a) argues that science can be re-envisioned as more inclusive through a greater understanding of the contributions of women scientists throughout history and in the present day. The “Morella Report” (CAWMSET, 2000) states that the public image of scientists is both “inaccurate and derogatory” and that women and minorities are not adequately represented. They recommend a transformation of this image that is positive and inclusive for all.

Women scientists can provide a voice to the way in which obstacles to practicing science are negotiated (Eisenhart and Finkel, 1998; Keller, 1983; Rosser, 1990; Schiebinger, 1989, Shephard, 1993). Their stories can illuminate the way in which science is socially situated as well as they way in which they have been able to work within the male tradition of science or work beyond that to re-envision more inclusive science. A project that seeks to discover the stories of women scientists would be consistent with the feminist critique of science and specifically create opportunities to consider the way in which gender and science are linked. In fact, many authors have called for the use of narrative in science education in which the stories of women scientists are used to inform and expand the image of science in the minds of students (Barton, 1997, Evans, et.al., 1995; Martin and Brower, 1991; Meyer, 1998; Richmond, et. al., 1998; Smith and Erb, 1986; Zachs, 1999, Rosser, 2000).

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22 McClintock was eventually awarded the Noble prize for her discovery of transposition in genetics.
Documenting the stories of women scientists does more than just provide additional information of who has practiced science; it has the potential to recreate the image of science. Joan Wallach Scott (1987, 1991) writes about the importance of woman’s history as more than just a supplement to what we know in history, it is actually a rewriting of history. This notion of rewriting goes beyond the facts to the actual notion of how history is determined and described. Scott (1987) suggest approaches to women’s history that require placing women in the historical moment of their times - socially and politically. These moments have to involve the role that gender played in defining women’s social situation. She writes

Feminist desires to make women a historical subject cannot be realized simply by making her the agent or principal character in a historical narrative. To discover where women have been throughout history it is necessary to examine what gender and sexual difference have had to do with the workings of power. By doing so historians will both find women and transform political history. (Scott, 1987, p. 43)
CHAPTER 3

Methods

Introduction

This study was developed around the belief that the lived experiences of individuals offer a valid and instructive approach to considering the significant influences in ones life. For women in science this is especially true because of the many barriers and obstacles (Kahle and Meece, 1994; Lazarus, et al., 2002; Monastersky, 2005; Rosser, 1990; Tobias, 1994; Wilson, 2004) they might face in pursuing science as well as the minority status they often hold as women scientists (Clewell and Campbell, 2002; Eisenhart and Finkel, 1998; National Science Foundation Report, 2002). The fact that science is often perceived as a predominantly male pursuit (Brickhouse, 2001; CAWMSET, 2000; Kleinman, 1998) means that generalizations about why and how people become scientists may be inaccurate or misleading for women. Through the use of oral history technique this study collected information about the lived experiences of seven women scientists. Through one on one interviews each women was asked to recount memories related to her interest and pursuit of science. This included family background and influence, educational experiences and ongoing experiences with science and scientific research. The use of oral history technique was meant to provide an open space where each woman could share what was most significant and meaningful to her in the pursuit of her career in science (Anderson and Jack, 1991). It allowed for personal reflection in an ongoing dialogue where significant moments could be recounted and considered in light of the present moment (Connelly and Clandenin, 1990). Clearly, not all memories can be retrieved by anyone, but it is hoped that the most significant ones
were brought forth and that the ongoing dialogue and interview guide allowed for memories to emerge.

The use of constructivist grounded theory as a framework acknowledged the interplay of the researcher and narrator in the interview (Charmaz, 2000). The questions asked by the researcher have significant influence on what the narrator remembered and elaborated on. This was true of the interview guide as it was established but also other questions that came in the course of the conversation. While the narrator was the teller of her own tale, what the researcher saw ultimately shaped what she measured and analyzed. Constructivist grounded theory acknowledges and addresses this interaction with the data through its methodology. The researcher played a significant role in constructing the picture presented by each woman in her oral history. It helped address concerns about doing an oral history and allowing the narrator to respond to the researcher’s interpretation of what she has narrated about her experience. Constructivist grounded theory also shifts the focus from an objective data set to “a discovered reality (that) arises from the interactive process and its temporal, cultural and structural contexts” (Charmaz, 2000, p. 524). It does not accept the positivist assumption that there is an underlying reality to be described, analyzed and explained through research. Rather oral history and constructivist grounded theory assume that there is a world made real through the words and actions of individuals and their experience. The researcher’s role was to bring that world into a public awareness that allows for understanding and interpretation in a way that brings meaning to the experiences of others.

Participants
Participants for this study were selected based on the following criteria;

- completion of a terminal degree
- at least 10 years of professional scientific experience
- publication of original research beyond dissertation

A pool of potential participants was developed through contacts with local universities as well as professional organizations that support the work of women in science (ie. WISE, Rowe Center for Women in Engineering). Twenty women were contacted in person, by phone or e-mail to determine their preliminary interest in the study. Those interested were contacted a second time and given specific information about the study and their participation in it.

In this study, seven women scientists representing science, technology, engineering and math (STEM) were interviewed. Table 1 provides a listing of the women, their STEM areas, degrees and current positions. Some women worked in more than one area. For example, Dr. Dunn is a computer engineer and represents experience in math, engineering and technology. Dr. Kendall’s background included engineering, chemistry and environmental science. Dr. Grant has degrees in math and biology. The women as a group represent work in education and industry although, at the time of the study, all had full time positions as scientists in a university. Each woman has a terminal degree in her field and has conducted some form of original research beyond her dissertation. As a group, the women in this study had from 10 to 55 years of professional scientific experience.
Table 1. Participant Information

<table>
<thead>
<tr>
<th>Scientist (Psuedonyms)</th>
<th>STEM Area</th>
<th>Terminal Degree</th>
<th>Current position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathy Dunn</td>
<td>Computer Science, math</td>
<td>Ph.D., 1990</td>
<td>Associate Professor, Electrical and Computer Engineering and Computer Science</td>
</tr>
<tr>
<td>Renee Grant</td>
<td>Biology, Geology, Mathematics</td>
<td>Ph.D., 1983</td>
<td>Professor of Biology and Pediatrics</td>
</tr>
<tr>
<td>Ellen Harris</td>
<td>Immunology, Medicine</td>
<td>M.D., 1965</td>
<td>Professor Emeritus</td>
</tr>
<tr>
<td>Mary Hawkins</td>
<td>Physics, Astrophysics</td>
<td>Ph.D., 1995</td>
<td>Associate Professor, Physics</td>
</tr>
<tr>
<td>Martha Kendall</td>
<td>Environmental Engineering</td>
<td>Ph.D., 2002</td>
<td>Assistant professor, Environmental Engineering</td>
</tr>
<tr>
<td>Kim Kramer</td>
<td>Physics</td>
<td>Ph.D., 1981</td>
<td>Professor, Physics</td>
</tr>
<tr>
<td>Jean Smith</td>
<td>Biology, Biogeochemistry, Botany</td>
<td>Ph.D., 1986</td>
<td>Professor, Biology</td>
</tr>
</tbody>
</table>

Data Collection

The participants completed a demographic survey (Appendix B) prior to the interviews. This provided preliminary information about their background and allowed for more time in the interview to discuss experiences. This included questions about family background, parent’s occupation and education levels and other aspects of personal history. Each woman provided curriculum vitae as well. At the first meeting, they were asked to sign the informed consent form (Appendix C) as approved by the Institutional Review Board (IRB). All interviews were conducted at the location of the participant’s choosing. It was important to conduct the interviews in an environment that was comfortable to them and free of intimidation in discussing the many facets of their life experience. The conversations were tape recorded and later transcribed.
Each oral history interview required two sessions that lasted approximately 1 ½ hours. The first interview guide (see Appendix D) focused on the influences of family, education and experiences with science. The interview started with some broad questions about their personal history focusing on family and education backgrounds. They were asked to talk about how they decided to become a scientist and any experiences that influenced them along the way. They were also asked to discuss social and cultural influences that were significant to them in their personal history. After these opening questions, more specific questions were asked in each of the three areas; family, education and experiences with science. Closing questions asked for them to offer information on areas they thought should have been covered, to list the three most significant areas of influence in their science careers and identify any regrets they may have had.

After the first session, the preliminary coding of data was done. Nvivo Software was used for data coding. Each transcript was read through and notes taken about significant areas of influence as they emerged for each participant. Through “memo writing” described by Charmaz (2000), this data was processed to consider emerging themes that the women held in common in the transcripts. These themes included the following:

1. Science identity and interest developed early in life and influenced by a number of factors.
3. Love for discovery, curiosity and problem solving as significant motivator.
4. Strong interest in helping others.
5. Significant stories of early experiences with science.

6. Strong sense of self and belief in abilities as science student and science professional.

7. An image of science that is social, personal and connected to personal experience.

8. Conflicts between personal and professional goals significant to experience.

9. Men as supporters, especially fathers for some.

10. Barriers existed throughout the experiences but were overcome by these women.

These were used to construct a guide for the second interview (see Appendix E).

The questions asked in the second interview were meant to modify what was expressed in the first round. These modifications included addressing any gaps in the data as well as any emerging theories or ideas about the woman’s experience. All the interviews were completed before the second round and comparisons were made between the women’s experiences. The questions in the second interview focused on defining moments, barriers and how they were overcome, the role of gender, stereotypes and the qualities of women scientists.

Interviews were tape recorded and transcribed by a professional transcriptionist. During the interview notes were taken as needed. The women were asked for supporting materials and documents to support their experiences. The data is stored on audio tapes and field notes. It was organized by participant and date and time of the interview.

*Trustworthiness*

Oral histories are clearly specific to the experiences of one individual, but it is possible to select participants who are authentic representations of women scientists. This method is consistent with the idea of phenomenological research and represents a
valid way to understand the way people experience phenomenon (Patton, 1990; Tierney, 2000). By looking for those with at least 10 years experience in science, an advanced degree in science and published research experience the participants could be defined as authentic in this profession. The criteria for selection offered some level of external validity that might allow comparisons to other women scientists.

The commonality of the social experience also related to internal validity. It is possible that other researchers would consider ways in which family life, education, and experiences with science affected occupational decisions and the scientific work of female scientists. In fact, the literature discusses the influences of many of these variables. Specifically, the experience of women in science has and continues to be evaluated based on social location as defined by a number of variables (Clewell and Campbell, 2002; Eisenhart and Finkel, 1998; Keller, 1983; Rosser, 2000; Scheibinger, 1989). As discussed earlier, oral histories are considered a valid and credible form of qualitative research (Anderson and Jack, 1991; Patton, 1990; Tierney, 2000). Moreover, oral histories have been used as a research tool to investigate the way women negotiate the pursuit of careers in male dominated fields (Anderson and Jack, 1991; Scott, 1987).

Overall reliability in this study is obtained by;

- Considerable literature review on issues concerning women in science and examples of women scientists.
- Participants were well informed of the purpose of the study and their role in it.
- Participants were well informed of the role of the researcher.
- The same questionnaires were used for all interviews.
• The data was analyzed in the context of the established literature.

• Information on the reflexivity of the researcher can be found in Appendix F.

Validity of the data was ensured by adhering to the following guidelines;

• There were established criteria for participation in the study.

• Participants in the interviews were deemed credible and met the criteria for participation.

• Curriculum vitae and demographic data supported claims of professional experience.

• Participants reflected the population of women in academic science professions.

• The data was analyzed in the context of feminist theories on science as well as published research about the interplay of science and gender.

_Data Analysis_

Audio tapes were transcribed and coded after the first interview. From these codes, memos or drafts were written that processed the information and discussed emerging codes. These memos were reviewed and used to identify follow-up questions for the second interview. Once the second interview was transcribed all transcripts were coded using line by line coding (Charmaz, 2000). This resulted in 85 nodes of coding. These codes were examined to determine common themes across the areas of experience. Not all codes were found in each transcript, but those in at least four of the seven interviews were considered for emerging themes. These codes were then grouped into six different
themes (see Appendix G) that related the women’s experiences and the areas of influence in their pursuit of a science career.
CHAPTER 4

Narrative of Findings

Introduction – Emerging Themes of Influence

The responses of each of the seven women scientists in this study painted a picture of the variety of life experiences and influences that affected their pursuit of a career in science. It is a picture that offers a complex mixture of ideas, emotions, passions, experiences and personal history. For each of them, becoming a scientist was a pursuit that was intricately woven with their own sense of identity from an early age. From their stories, it was possible to identify six themes that define the factors influencing their experience of becoming and being scientists. Appendix G provides a listing of those themes and the coding nodes that were grouped within them.

Each woman was specifically asked to name the three most significant areas of influence for them in pursuing science as a career. This alone did not determine the six themes, because other questions in the interview helped to elaborate on areas of influence and the themes that emerged from coding the entire transcript. Rather this question provided a focal point for the women to stress factors that seemed to matter to them most. The areas of influence are listed in Table 2 and include school, research and practical experiences; support from others such as mentors, teachers and parents; childhood experiences; high school classes; a special ability in science; sense of responsibility for others and alternate images of scientists. Each of these offers discussion points within one or more of the themes listed. For example, practical experience, school experience and childhood experience with science are an important part of experiences with science.
A sense of responsibility for others developed into an ethic of care that was evident in others aspects of the coding. Some areas of influence in this table did develop as an emerging theme, such as support from others including parents and the desire to help others and solve problems (ethic of care).

Table 2. Significant areas of influence (listed in order given by participant)

<table>
<thead>
<tr>
<th>Participant (Psuedonym)</th>
<th>Influence 1</th>
<th>Influence 2</th>
<th>Influence 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathy Dunn</td>
<td>School experiences</td>
<td>Practical experience</td>
<td>Special ability in science</td>
</tr>
<tr>
<td>Renee Grant</td>
<td>High school geometry class/teacher</td>
<td>Male mentor</td>
<td>Early research experience</td>
</tr>
<tr>
<td>Ellen Harris</td>
<td>Childhood experiences</td>
<td>Male mentor</td>
<td>Help others/cure disease</td>
</tr>
<tr>
<td>Mary Hawkins</td>
<td>Practical experience</td>
<td>College professor - female</td>
<td>Support from others</td>
</tr>
<tr>
<td>Martha Kendall</td>
<td>High school biology/chemistry</td>
<td>Practical experience - Science camp</td>
<td>Alternate to male caricature of engineer</td>
</tr>
<tr>
<td>Kim Kramer</td>
<td>Childhood interest/encouragement</td>
<td>Male mentor</td>
<td>Support from others</td>
</tr>
<tr>
<td>Jean Smith</td>
<td>Parental support/father</td>
<td>Sense of independence</td>
<td>Sense of responsibility for child – solve problems</td>
</tr>
</tbody>
</table>

The emerging themes of influence are listed in Table 3. For each one a list of descriptors is given that helps define the theme. For example, passions of the mind included a love of the intellect, love for science, valuing curiosity and discovery and a drive to create or model solutions. The other themes were experiences with science, support of others, ethic of care, self efficacy in science, and belonging vs. marginality. The narrative of findings expands on each of these themes and what the women had to say about them. Each of the women had developed their own sense of identity as a
scientist and displayed strong agency in their pursuit of the field. These themes are seen to have had a significant impact on the identity and agency these women possessed in pursuing their science career.

Table 3.

**Emerging Themes of Influence and Descriptors**

<table>
<thead>
<tr>
<th>Experiences with Science</th>
<th>Childhood experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily and family life</td>
</tr>
<tr>
<td></td>
<td>Informal science</td>
</tr>
<tr>
<td></td>
<td>Practical experience</td>
</tr>
<tr>
<td></td>
<td>Formal education</td>
</tr>
<tr>
<td></td>
<td>Research projects</td>
</tr>
<tr>
<td></td>
<td>Professional life</td>
</tr>
<tr>
<td>Support of Others</td>
<td>Parents</td>
</tr>
<tr>
<td></td>
<td>Mentors, role models</td>
</tr>
<tr>
<td></td>
<td>Peers</td>
</tr>
<tr>
<td>Passions of the Mind</td>
<td>Love of the intellect</td>
</tr>
<tr>
<td></td>
<td>Love for science</td>
</tr>
<tr>
<td></td>
<td>Value curiosity/discovery</td>
</tr>
<tr>
<td></td>
<td>Drive to solve/model/create</td>
</tr>
<tr>
<td>Ethic of Care</td>
<td>Desire to help others</td>
</tr>
<tr>
<td></td>
<td>Interest in teaching/mentoring</td>
</tr>
<tr>
<td></td>
<td>Fix problems in the world</td>
</tr>
<tr>
<td></td>
<td>Apply research to real world</td>
</tr>
<tr>
<td>Self Efficacy in Science</td>
<td>Strong sense of science identity</td>
</tr>
<tr>
<td></td>
<td>Affirmation as good student</td>
</tr>
<tr>
<td></td>
<td>Sees self as good student</td>
</tr>
<tr>
<td></td>
<td>Commitment, drive, persistence, independence</td>
</tr>
<tr>
<td>Belonging vs. Marginality</td>
<td>Accessing community of scientists</td>
</tr>
<tr>
<td></td>
<td>Importance of collaborations</td>
</tr>
<tr>
<td></td>
<td>Values standing out as minority</td>
</tr>
</tbody>
</table>
**Personal Experiences with Science**

The stories of each of the women interviewed in this study highlights personal experiences with science throughout their lives. Connecting personal experience with science is a fundamental component of feminist pedagogy in science education (Barton, 1997; Brickhouse, 2001; Lee and Burkham, 1996; Meyer, 1998; Rosser, 1990; Roychoudhury, et.al., 1993). The personal experiences of these women ranged from childhood through adulthood and included experiences from daily and family life, science clubs, part-time work, formal education, research projects and professional life. This particular theme is significant for several reasons. It indicates a life long interest in science; it shows the importance of practical or hands on experiences in science; and it conveys the ways in which these women experienced and dealt with stereotypes of science, including the influence of gender in science.

**Childhood Memories**

Lee and Burkham (1996) found that childhood experiences at home can impact further learning and interest in science. Each woman had stories from childhood and family life that indicated an early interest in science. Comments like the following from Dr. Kramer were typical;

Well, I think I knew from when I was pretty young that I wanted to be a scientist of some type. I think I announced to my parents when I was six that I was going to be a scientist. I had gotten... a book of science experiments as a gift when I was about six and went through...children’s experiments, Ph tests...

They talked about their sense of that interest from very early on, as if they had a calling to be scientist, but they also discussed ways in which they experienced science at a young age. Not only did these incidents indicate an early interest in science they also
revealed ways in which the scientific experience was part of their own lived experience as children. This was combined with a natural curiosity about the world. The women spoke of being motivated by a very personal interest in the world around them as children as opposed to specific school experiences that required some participation in this sense of discovery. However, these school experiences were also part of their personal experience with science. The sense of curiosity seemed motivated by different desires: a love of the natural world and universe, an interest in the way things worked, questioning the workings of the human body, and the incidence of illness and disease. Dr. Harris talked about childhood experiences with illness and death. She shared an article she wrote about why she became a doctor. It was focused specifically on memories of children she knew who were ill, injured or had died. She also said her friend’s father was a physician and she would look at his medical books whenever she had a chance. Those books included pictures of injured WWI soldiers and she recalled the “attempts of plastic surgery to repair those awful faces.” In her interview she also said,

There were quite a few medical problems in my family, which was also probably a reason why I got interested in medicine.

When asked about what influenced their decisions to go into science, Dr. Grant and Dr. Dunn spoke of their childhood curiosity;

I did my first science experiment before I was six years old because I can remember where we lived and, it depends on what you count as science, because I also remember when my sister was born when I was four and I remember I wanted to know where eyes went when they closed. I remember going into her crib and opening her eyes and she saw me. The other one was just putting a coffee cup with water outside on the window ledge and just seeing how through September through December how cold it got and how frozen it got each morning. So, I suppose in that sense I have always, I think I always wanted to be a scientist.
And I found out about the big bang theory and I walked into the kitchen and said, “Mom, what’s the big bang theory?” I was five and I don’t remember that but she remembers that so it was pretty clear that I was precocious and interested in the universe and science.

It seemed they had a sense of being born as a scientist. Traweek (1988) speaks of scientists being born not made in her discussion about male physicists in her book *Beamtimes and Lifetimes.* As she writes, it seems a life long interest that seems to have always been there. For these women it was like a calling with which they were born.

Many referred to ways their childhood environment encouraged them in their curiosities about scientific things. This would include a feeling of being in a nurturing environment that supported their interests and being given the opportunities and encouragement to explore things. Memories included the overall support for education and learning as well as specific support in science. Dr. Dunn described the love of books in her home even though her parents were not well educated. Going to the library was a memorable family event.

There were a lot of books in the house and they bought me books. I don’t ever remember not having anything I wanted in terms of books. I even asked for a chemistry set one year and they bought that for me so they were encouraging. All along that was probably why I was so oblivious was because I was in such a nurturing environment.

Dr. Dunn remembered her families love of reading in much the same way she remembered the nurturing environment in which she grew up. She connected this with her own interest and pursuit of a career that required a love of curiosity and desire to know more about things.

*Practical Experiences*

Beyond childhood experiences, the women told stories of ways in which practical experiences with science were important and/or memorable to them. Others have written
about the positive impact of informal science experiences – those not necessarily part of formal schooling (Farenga, 1995 (in Clewell and Campell, 2002); Kahle, 1990; Lee and Birkham, 1996; Stake and Mares, 2004). Science educators have realized that it is important for science students to be able to relate science to the world they live in (Barton, 1997; Brickhouse, 2001; Meyer, 1998; Milne, 1998; Richmond et.al., 1998).

The practical experiences for these women would include field trips to places where they could see scientists at work, summer work experiences in such places as pharmacies, nursing homes and marine labs, school research projects, science camps, co-op positions in college and field work with other scientists. In following quote, Dr. Smith expresses the importance of this type of experience in making the science more appealing and real to the scientist. She obviously values science for its ability to produce something useful.

She connects her interest in science with hands on experiences that allowed her to do something “real”.

the ones that were actually doing research would take us out and do real things, I thought that was more of an elaboration of just being smart….It was actually being able to do something. So I think at some point in time, I noticed as an adult too, I like to build things and I like to make something work…and even in the lab I like to work on the machines and see stuff get done. So, I think somewhere in that phase when I saw people really doing things I thought, ‘Oh, that’s cool.’ When I was a tech at Colombia those people were going out on boats collecting real data and then they’d bring it back to us and we’d really have to do something with it and you’d see it go from numbers, you know, sheets of paper every where…and we’d make maps that we could actually say this is what the floor of the ocean looks like. There was something to that that appealed to me.

For Dr. Hawkins, interest in science as a profession became clear to her during a summer job experience. She had not considered herself the best science student but her experience affirmed for her that she had some talent in this area and encouraged her to pursue that talent. It is interesting that she ended up in a science field (astronomy) very
different from what was involved in the job experience (health care), but the experience alone encouraged Dr. Hawkins in some basic science courses that were building blocks for her future endeavors. Dr. Kendall cited a summer research program as a high school student as a significant influence for her. The program was sponsored by a major university and targeted potential female scientists. She liked the focus on women and the practical experience she had with scientific research.

The women talked about how these practical experiences in science continued throughout their careers as students and influenced future decisions they made about their scientific pursuits. Dr. Kendall said

And that stayed with me in college and, in fact, when it was time to sign up for little project groups as a freshman I got into a water pollution group because of my interest that was sparked in high school.

Some also found that these experiences guided them away from areas of science that were less appealing to them. For Dr. Dunn, a computer engineer, work in a pharmacology lab convinced her that she would not be happy working with all the “squishy things” of science. Examples were also given of how they were able to build on knowledge and experience, refine their interests, and develop skills they would find useful as they continued to pursue science. It is likely these benefits also contributed a sense of confidence about being a scientist. Many saw these experiences as not only helping to refine their interest but creating opportunities for them in the professional world.

For most of the women, school experiences with science were remembered as positive. This is not consistent with some of the literature that girls feel uncomfortable and disengaged in science classes (Kahle, et.al., 1993; Rosser, 1990; Roychoudhury, et. al., 1995).
al., 1995; Sandler, et. al., 1996). These women would list subject areas in science and math that they loved and felt they did well in. These were reinforced by practical experiences they would have in school that included experiments, problem solving, research and field work. Discussions about their interests in research in later years would often refer back their early interests in studying things and always wanting to know more. When asked about how she decided on astronomy Dr. Hawkins replied with the following.

I also really did like doing the research stuff. I loved reading the papers and investigating stuff. It was actually like this when I was young even. I remember, you know, we used to have these encyclopedias at home.... You go to research something you were supposed to do for a class project or whatever and three hours later I have gone all over the place and hadn’t got anywhere near working on my project and I still do that now.

This does not refer specifically to her choice of astronomy, but the significance of doing research into ideas that interested her and how she was motivated by class projects in school. It also underscores the motivation of her natural curiosity to know more and go beyond the original question. These school experiences with science were also places where these women realized the practical applications of science in the everyday world. They could see ways in which they could take knowledge and information and apply to specific areas of need. As a college student, Dr. Dunn realized the practical challenges of managing databases.

I ended up doing my research in the area of database systems and I had a clue about that as an undergrad. I took a database class and I thought that it was both challenging intellectually but it was also very practical and the bottom line is that people want to get data out of the database and it’s got to perform. You can’t have them waiting three hours for answers to their queries.
Dr. Kendall talked about how her interest in environmental work was influenced by a water pollution project she did as a freshman in college. She always felt concern for the environment and was able to see in a practical way how she could work in that area. On the whole, these practical experiences mattered to these women in the way they made science more real to them.

**Encountering Stereotypes**

It was obvious from the recollections of these women that images of science do not always reflect reality. The women’s personal experiences with science also give examples of ways in which they encountered various stereotypes about science. The feminist critique of science challenges the historically male dominated vision of science as a purely objective endeavor that is impersonal, anti-social and lacks creativity (Bleier, 1986; Harding, 1986; Keller, 1985). This vision of science reflects a predominantly male image of the field (Bleier, 1986; Keller, 1985; Haraway, 1988; Harding, 1991; Kleinman, 1998). The experiences of these women highlight ways in which they encountered these stereotypes, but also how they tried to dismiss them. While they acknowledged stereotypes about science in different ways, these women did not allow those stereotypes to be barriers to their own pursuit of a science career. In some cases they took advantage of opportunities to dismiss these stereotypes, in classes they taught, the way they mentored students or by talking to younger science classes. The practical experiences they had with science convinced them that the stereotypes were untrue. For example, research experiences dismissed the idea that science is not creative or that it is antisocial. Even to this day Dr. Kendall finds people challenging the notion of creativity in science.
This whole...scientists are impartial and unemotional and that’s not true at all or they are not creative. Science is one of the most creative fields you can get into in my opinion. People say, “You’re so creative, how can you stand to be an engineer?” Oh my gosh, you know, at least in the academia and in research that’s the piece of it you need.

Many talked about the collaborative nature of their experiences and the ways in which working with others was a benefit in their experience of science. Dr. Kramer discussed the significance of the research group in choosing a research project. This is contrary to the male image of the scientist as a loner described by Keller (1986). It also presents a different picture than those described by Eisenhart and Finkel (1998) in their analysis of women working at the margins of science. The fact that these women work in academia may explain the difference, because Eisenhart and Finkel’s subjects are in more marginalized professions of science. However others describe women as marginalized academia as well (Lazarus, et.al., 2002; Rossiter, 1982; Wilson, 2004). The ways in which these participated with others in the scientific community and challenges of discovery that require a creative and collaborative mind were significant motivators for these women.

Several of the women found some of the aspects of the scientific enterprise as unappealing. In some ways these aspects contribute to stereotypes about science. While these women acknowledged them, it was clear they either found ways to deal with those unappealing aspects or ways to avoid them. Examples of these include the inhumane treatment of laboratory animals, the antisocial nature of science, heavy emphasis on procuring grant money over teaching, overemphasizing precision and neatness, processes that are not open to ongoing investigation, and valuing publications and citations over other contributions such as mentoring and teaching students. Wilson (2004) cites
political infighting and competition over money as ways in which women get disillusioned with science in academia. While the literature suggests that the projects of science are unappealing to women (Keller, 1985; Kleinman, 1998; Rosser, 1990) this study suggests that is not always the case and women find ways to work within science on projects that are appealing to them. While some of the women expressed frustration over issues like this, they did not seem to deter them from their goals as research scientists at the university where they worked.

For Dr. Dunn, the inhumane use of an animal for a demonstration convinced her that she should consider other fields of science. It also is an example of how scientists, in this case a lab assistant, can perpetuate these stereotypes.

We did a workshop where a lab assistant injected a mouse, a living white mouse, with a chemical that caused an epileptic seizure. And so this poor little mouse is flopping all around on the table and then I said, “Are you going to cure it?” I assumed that was what the whole thing was about is that you were going to show us how to induce epilepsy and then you can cure it. And the lab tech says, “No.” They just let the mice die. It was the hugest turn off. I thought what idiot brought high school young women and young men in here and murdered an animal in front of them?

The seemingly inhumane projects of science are not uncommon and is cited as one of the reasons more women do not pursue science as a career (Rosser, 1990).

The experience of these women certainly reinforced science as more of a social enterprise than an individual pursuit. They all referred to doing science with other people in research groups and various collaborations. They would discuss the ways in which science is anything but impersonal and that it provides many opportunities to work with others not only in research but also in teaching and advising students. This idea of participating in the community of scientists is furthered discussed in the section on marginality vs. belonging.
Stereotypes about women in science were acknowledged by several of the women, especially in terms of the image of a scientist as a “balding man with glasses and a white coat”. This male image of science is discussed in the literature (Harding, 1991; Kleinman, 1998; Rosser, 1990; Rossiter, 1985) and a potential area for creating change about who actually can and does practice science. To whatever extent any of these women had that image of a scientist it did not seem to deter their own ability to see themselves as scientists. Dr. Grant talked specifically about how, as a child, she took a Barbie Doll with a white dress and turned it into a scientist; removing the lace and making it look more like a lab coat. Dr. Kendall and Dr. Dunn talked about how their own work as scientists helped to dismiss that image for themselves and others.

The camp at Purdue and as far as staying in it and probably coming to terms with the character, caricature of a typical engineer, didn’t have to fit...you know, that I could find a way to use my talents and find work.

Well, when I go out and talk to kids at schools, in high schools, elementary schools, middle schools, whatever, I figure half of what I’m doing there is just saying somebody who looks like me can do this work and isn’t it cool.

In spite of the male image it was also noted that certain types of scientists were more likely viewed as female in particular medical doctors. This is interesting in that recent statistics indicate this is one of the fields where women match if not exceed men in the numbers of those entering medical programs. A recent study cites that women make up more than 50% of matriculating students in medical schools (Association of American Medical Colleges, 2003). Dr. Harris referred to a recent article on women in medicine (Levinson and Lurie, 2004) that described how the profession was becoming “feminized”. The authors (both women) suggest that the medical profession might benefit by becoming more patient centered but could face disadvantages in that women
might lower the status of the profession. Dr. Harris and several of her colleagues took issues with this article and its implications that women practice medicine in a way different from men or that they might lower the status of the profession. Dr. Harris’ work in immunological research, for which she has received international acclaim, is an example of just the opposite.

**Experiences with Gender**

The interplay of gender and science is one source of stereotypes about science that can affect the participation of women by sending messages that women are not meant to be scientists (Harding, 1989; Keller, 1995; Rosser, 1990). Many of the women had experiences with science that were clearly influenced by their gender although not all would acknowledge that gender was an issue in science for them personally or that it kept them from pursuing science. By the time each of these women was in graduate programs they were finding themselves a minority in their classes and departments. Wilson (2004) discusses how women still find academic departments unwelcoming and sometimes hostile and attributes this to the low persistence rates in some fields. These referred to different experiences that reinforced this status or made it obvious that women were often second class citizens in this field. Some shared experiences of how women were not meant to be a part of this “manly science”. For some these were male professors who sent negative messages about being a woman in a science or math class. Dr. Dunn referred to a professor in a graduate class she had in the early 80’s.

He ridiculed people for their comments and he had publicly stated that he didn’t think women belonged in computer science. So, we all dropped the class. Eventually it was just male students and he revamped the course. He threw out all of the nasty assignments and stuff and he made it open-ended.
In spite of this outwardly negative treatment by a male professor, she stayed in computer science and found other classes and other professors. Sometimes these messages were as pointed as making the women know they were not welcome to some degree creating hostile environments, other times they were more subtle. Some women acknowledged the fact that it was not good to show your name as female on papers and proposals because they would be more likely judged as insufficient or held to different or higher standards. There was discussion of lower expectations for women as well as ways in which women were made to have less confidence or view themselves more critically than men would. Steinpres, et. al. (1999) found that women are more poorly evaluated by both men and women than men with the same credentials. Dr. Hawkins explained that she did not use any identifier in her name that would reveal her gender. Similar to Steinpres, et. al. (1999) she found that women are as likely to have this bias as men.

But it’s harder being a woman because even women, not just men, you immediately perceive less quality if you’re a woman, it’s been shown already that when you have somebody review a paper and the average review will decrease if you make the name a female name verses a male name with nothing else changed and if you have initials and they can’t tell it’s somewhere in between. So that’s why I don’t have my full name on my papers.

Dr. Kendall spoke of a feeling of not being taken seriously as a woman when she first joined the department. She also had the sense that she was “hazed” in a way to send a message about her status. She did feel that she could overcome this eventually.

Who knows, if I’d been a male then maybe they would have done the same thing. I have no way of knowing but it felt frequently like I wasn’t taken seriously, for a while. Once the people got to know me that would drop away but always in a new situation people’s immediate assumption would be...

The use of affirmative action was referred to several times in the context of getting jobs or opportunities because they were women and not because of the quality of
their work. Some of the women discussed the ways male colleagues would point this out to them and often made them feel as if their work might be substandard because of this. There was often an underlying expectation that the women would end up at home as a wife and mother and their success therefore might not be as important as the man’s in this field.

Comments have been made sort of suggesting that, you know, it’s not that important that I succeed because of course I can always just get married and stay home,...where for a man of course he has to have his career, what else is he going to do, he can’t stay home,...those kind of really subtle things sort of suggest that it’s not that important that you work that hard.

In spite of comments like these, each woman did work hard and continue to pursue her goals. As discussed in the section on self efficacy, these women pointed to the importance of being stubborn and persisting in what they wanted as valuable qualities for them.

One suggestion of the feminist critique is that women would approach science differently from men because of the social impact of gender (Eisenhart and Finkel, 1998; Harding, 1998b; Rosser, 1990). While their approach to practicing science is in fact different from that presented in the male stereotypes about science, the personal experiences with science for the women in this study tend to suggest that for them it is not clear that women practice science differently from men. The women focused more on differences between individuals than those specific to gender. There was some acknowledgement that women might be more empathic and collaborative, or that they might choose certain professions over others, but this was not an overwhelming notion. The overall perspective on this issue may be characterized by the following quote from Dr. Grant,
And so the concept that there is a male and female science out there is wrong. There is a reality out there and different human beings have different approaches for discovering it and there may be that as a woman I approach it differently than a man would but that’s okay. Is that a male way of doing science or is that a female way of doing science....have I been forced to do male science? No. I’ve been forced to do science the way the people who taught me to do science believed in it.

She is very explicit about the fact that science is done from the approach of different human beings and not determined by one’s gender. This notion seems to go along with the idea that these women tended to separate experiences of gender in science from themselves. It is also consistent with the idea that they had claimed a science identity for themselves based on their own interests and beliefs.

These was some impact of the predominance of men in the departments in which they worked (this is discussed further in the section on marginality vs. belonging). Some sentiment was expressed that women had to take on a “male” approach to practice science successfully. Dr. Kendall talked about how she saw this in her field of engineering,

A lot of the women tend to pattern themselves after the male. That’s a way to be successful and that’s true if you want to be successful to a certain degree, take on those characteristics.

Eisenhart and Funkel (1998) describe this as resulting from a gender neutral discourse in which women have to compromise identity to fit in. However, this did not seem to be a pervasive pattern for most of these women.

Women in science often experience conflict between their personal and professional goals and some have suggested this keeps a number of women out of science especially in academia (Bozeman, 2004; Kulis and Sicotte, 2002; Wilson, 2004). Related to this many of the women in this study felt that women experienced the conflict of roles
in work and personal life to a much greater extent than men did. They recognized that they were expected to choose between work and personal goals at a greater level or frequency than their male counterparts. Many of these women postponed personal goals (such as child bearing) for their own professional goals recognizing that those personal commitments would get in the way of their professional progress. For those who pursued personal goals, they expected they would make some professional sacrifices to do so such as tenure, merit increases and grant funding. The women who did have children found ways to balance their time between work and family and did not express regret over anything they might have sacrificed. Dr. Harris expressed concern that the presence of more women in science was changing the expectations about the amount of time one needs to spend in the lab. She observed that the younger students both men and women spent much less time in the lab than her contemporaries when they were starting their careers.

While there were these references to how gender was reflected in their personal experiences with science, the women also saw much of the gender influence as being outside their own experience. They would acknowledge that certain things happened but would indicate that it probably didn’t affect them directly - if at all for some. Dr. Harris who was passed over for the presidency of a professional organization after she had served as vice president acknowledged that it was probably because she was a woman, but stressed that this did not bother her. Overall, she was convinced that gender was not a central issue for women having access to science even though she did see women’s access to science as limited in some ways. Dr. Harris was most explicit about her beliefs that access to science is really not about one’s gender.
I think people always think of it as an issue. I really don’t. You are who you are and the world is all around you and go get it and that’s it.

While she was more explicit than the others about this, her attitude that you “go and get it no matter” what would be shared by several of the women. If gender was an issue, it was just a barrier to be overcome. It was not unusual for these women to acknowledge some experience with science that was influenced by their gender and then to make it less personal for themselves. Dr. Kramer does so in the following statement,

I think what I experienced was less personal but I know that other women have talked about it so it’s not uncommon. And what I experienced was more subtle I would have to say. I’ve had, and mostly after finishing my PhD, I would say, well, one thing I would say is a lot of men have some attitude that it’s now easier for a woman to get a position because of affirmative action.

Many of the women acknowledged that women in general have been sought and recruited for science professions through programs like affirmative action, university recruitment programs and other ways that focus on getting women in the sciences. Their own personal experience with science has either taken advantage of some program like that or been affirming enough to send them the message that women can and should do science. Negative experience related to gender became obstacles that were overcome and seemingly outweighed by the number of experiences that were positive and affirming. For all of these women, those affirming experiences started early on when they were in grade school or high school and for most even before school age. For these women these experiences were also supported by a caring family environment that valued learning and education and allowed them to develop a belief about themselves that they could be scientist even when her family was not sure of what that might mean.
Many women scientists have cited the support of family (Beoku-Betts, 2000; Farenga and Joyce, 1999; Kahle and Meece, 1994) and specifically parents (Clewell and Campbell, 2002; Kahle and Meece, 1994) as significant to them in becoming scientists. Parent expectations can have a significant effect on a girls’ desire to pursue science (Clewell and Campbell, 2002; Ethington, 1992; Farenga and Joyce, 1999). The family circumstances of the women in this study cover a broad range of educational and socioeconomic backgrounds. One woman’s parents had not completed school beyond the eighth grade while another’s were university professors at an Ivy League school. Nonetheless, one common theme for all was that education was central to the families’ values at some level. For some it was just a given, for others it was a way out of poverty and for all it was the means to an independence that was important to each of these women. Not all parents directly supported the pursuit of science for these women, but for each woman there was some level of support for them to become educated. This was sometimes even contrary to the experiences of the family, for example, in the cases where the parents were not educated or were concerned about girls doing something more traditional, such as starting a family. At some point, each women felt the support of her family to pursue her goals to become a scientist. This might have been by example because family members were educated or in professional fields or because the parents were explicit about their support of the women and her intellectual pursuits. There was acknowledgement that having a nurturing family environment as a child was a factor in
believing that one could be whatever they wanted to be and that the family support was there for that.

I think probably the nurturing family environment also contributed and I had good self-esteem. I never doubted that I could do what I was doing and it never even crossed my mind to doubt because I had such a loving environment at home.

Fathers and mothers were sometimes seen differently in the way they supported each woman. Some mothers were professionals with terminal degrees; others were housewives, with or without formal education. While there was support from their mothers the messages seemed more mixed than support from their fathers. While some women felt directly encouraged by their mother to pursue education and a profession, others got mixed messages about being a wife and mother first. The experiences ranged from Dr. Grant whose mother said a doctorate would be much more useful than a husband to Dr. Smith whose mother wondered how long she was going to delay her life by staying in school. However, several of the women discussed how their mothers gave them a sense empowerment because they taught them to seek independence and self sufficiency whether they supported science as a career or not. This was either because their mothers had overcome great hardships or because the women did not want to end up in the roles their mothers played.

Fathers were often cited more specifically as being very supportive and sometimes a role model for the woman and her career in science. Often the best role models are considered to be women (Evans, et.al., 1995; Kahle and Meece, 1994; Rosser, 2000). For most of the narrators, their fathers sent them powerful messages that they could do science and those who were scientists themselves were role models for their daughters. Dr. Kramer’s father expected his daughter to follow in his footsteps.
...my father was a successful physicist so I didn’t see why I couldn’t be.... I think in terms of support from the family, there’s no question. I suspect my father had decided when I was very young that I was going to be a physicist.

Sometimes the women talked about doing things with their fathers that were science related. It might have been working on some project around the house in which they were allowed to participate, helping with homework or attending a meeting where they met other scientists.

Dr. Kendall talked about how she spent time with her dad in his shop in the basement and was able to learn how to use some of his tools. He was an engineer also and Dr. Kendall felt that this fact and the experiences she shared with him as a child were very significant to her becoming an engineer. She and several others talked about how they got the message from their fathers that they could be anything they wanted to be. Dr. Smith, when talking about the most significant areas influence for her in choosing a career in science, said this of her father,

I always say it to everybody, especially those men who have daughters.... I did as a kid have somebody who told me, “Oh goodness gracious, the world revolves around you. You are the center of the universe.

These women did not get the message that girls should not be scientists and sometimes were explicitly told that they could in fact be a scientist.

Influential Others
Every one of the women talked about other influential people in their lives who supported them throughout the pursuit of their careers in science. These were men and women, although it was much more common for them to be men. They were teachers, professors, advisors, mentors and sometimes peers. They saw these people as supporting
them in some way through encouragement and example. They received affirmation from them about their own abilities, were challenged to make themselves better and to think about what it was they wanted to do with their science careers.

I think the behavior of people in my professional life made me think: where do I want to be, what do I want to do and how do I want to do it?

I think it’s really important that you have faculty, people that you really look up to whose opinions you think are unwavering and, that really believe in you.

I had large numbers of mentors and I can divide them into two pools. There are people like Charles and my mother and father who absolutely believed in me and think I’m wonderful. There have been mentors with whom I have struggled greatly....there was some truth to Steve’s critique of me, but nevertheless, I do not put him in the group of people who love me no matter what.

For each woman, there was at least one high school teacher they could recall who had a positive impact on them, even if that person was not in the sciences. The most common statement about a teacher was that they gave them encouragement about being in science or math. They were also remembered for making science fun and enjoyable.

Research on the impact of role models and mentors has indicated that this can be a significant influence for women in science (Campbell et.al., 2002; Goodman Research Group, 2002, Montelone, Dyer and Takemoto, 2003). However, Wilson (2004) suggests that women may not compete as well in doctorate programs because they have male advisers – who may be less comfortable with female students. Lazarus, et. al. (2002) suggest that as a minority in most programs, women may have a harder time with advisors than their male counterparts, especially if their advisors are male and may not be able to relate to a woman’s experience. This did not seem to be the case with the women in this study. More importantly, each woman had at least one significant male who served as a mentor and/or role model for her. Most of the time this person was the major
advisor in the women’s graduate program. This person would often challenge them to questions things, to think more deeply about their research interests, and serve as an intellectual resource to them in their field.

He was like another father to me in a way. He taught me how to think. My whole first year with him I would go in and be terrified to talk to him because he never, he always argued with me, and then my family, we never argue with each other. Everything I would go in and tell him I was going to do, he would argue with me about it until I was talking to him in the hall one day and I got to know him better and realized in his family debate was a sport.

Men might be viewed as gatekeepers in women’s access to science careers, especially at post graduate levels where programs are predominantly male. For these women, this function was mostly positive. Many times this mentor helped to introduce them to opportunities in their field through research interests, coursework and helping them to make contacts with the scientific community. These mentors would get them opportunities the narrators might not have had without them. They provided encouragement and helped with self confidence, some even described the relationship as nurturing. Some compared these mentors to the level of support they got from their parents. There were also some negative experiences with male mentors that mostly centered on difficulty in communicating or “connecting”. With the exception of one woman’s story, these experiences were handled by moving on to another mentor or advisor. Dr. Grant stayed with her major advisor who had an international reputation for his work. He clearly challenged Dr. Grant but did so in way that she found derogatory and unpleasant. She described him as having “zero social skills.” Nevertheless, she persisted in her work with him and moved on to develop her own reputation in science. However, it was apparent in the interview that Dr. Grant still holds a sense of resentment.
towards him for his treatment of her even though she felt he had significant impact on her work as a scientist.

Female influence also played a role in supporting these women but it was not cited nearly as frequently as the male influence. This may be because there were more males in the environment to serve in this role. The women who spoke of a positive influence from other women did so in terms of them being role models or as Dr. Dunn put it “life models”. Being able to see how other women functioned as scientists was influential and helpful. These women also provided encouragement about being to do science and try specific fields. Dr. Dunn emphasized the level of trust that was significant in the impact another woman had on her.

So, I ended up being recruited in graduate school by my advisor, who’s a woman, she encouraged me from the first class I took with her to do a masters degree with her and then to go on to PhD and to teach. There were times that I didn’t know if I was going to be cut out for that but her encouraging…I trusted her. That’s what it boils down to. I had tremendous respect for her and trust and when she told me I could do something I believed that I could because she said so, not because I thought I could or necessarily wanted to, but because somebody I trusted said I could do it.

This positive influence from other women often provided affirmation about the young scientist’s ability in science.

While each of these women acknowledged the minority status of women in their fields, at least early on, it also seemed significant that they saw other women, no matter how few, participating in the field. Dr. Kramer cited the fact that she knew of another woman in the department she was applying to as significant to her in reducing any worry about being a minority. Though few, her female school peers in physics classes and the fact that she saw some women in the field, affirmed for her that women can be physicists.
I do remember at my MIT interview being asked by the interviewer, you know, “Aren’t you worried because there are so few women in physics, is that a worry for you?” You know, it wasn’t a worry I would say and certainly I had some. My high school was a pretty academically oriented high school, a public high school but half the students are professor’s children and there was a woman in the class ahead of me who had gone to MIT and majored in physics so it wasn’t unheard of and in fact, I probably mentioned before, there was another woman in my class who became a physicist and the best physics students in the high school were women. So it wasn’t, at that stage, a matter of lacking role models or encouragement.

And later when talking about a friend of her families that her mother introduced her to,

I didn’t know very much about her but my mother told me she was a physics professor, you know, so I certainly became aware that, you know, women in physics are not unusual and there are a couple and certainly the possibility is not going to be precluded for me.

It seems just knowing that there were other women in the field, no matter how few, was significant to some of these women.

Overall, each of these women acknowledged that having a supportive and nurturing family and someone to serve as a mentor or role model was significant to them. They each felt that they had benefited from having at least one person exert a positive influence on their pursuit of science. For most of them it was more than that and each had examples of men and women who filled this role for them in some way.

*Passions of the Mind*

*Love of the Intellect*

While stereotypes of science supported by a male dominated image create a vision of a disconnected and dispassionate discipline, it is hard to imagine that the numerous scientific discoveries of the world resulted from such an approach. Intuitively one would think scientists would have a great deal of passion for the subjects they study, if only from that initial sense of curiosity but likely sustained throughout the challenges and
often tedious nature of scientific research. Much of the feminist critique of science seems to focus on the idea that a “male” science lacks this sense of passion (Harding, 1989; Rosser, 1990). There are surely exceptions and one is Traweeke’s (1988) study of male physicists in which she describes physicists “love affair” with their research. Years earlier, Michael Polanyi (chemist and science philosopher) began writing in the 1930’s about the importance of personal knowledge, faith and intellectual passion in the pursuit of scientific knowledge although his work received little subsequent notice (Jacobs, 2000). Nonetheless, science is characterized by this dispassionate stereotype. However, the stories of these seven women present a much different image and possibly one more closely aligned with the reality of the nature of science.

From the descriptions of early childhood experiences and interest in science, it was clear that these women had a passion or calling in the sciences that most recognized early on. This is only part of what became another apparent theme – “the passions of the mind”. This includes not only a love and enthusiasm for their specific science field but a deep love of the intellect in general. This passion include interests in a variety of subjects; a sense of natural curiosity and wonder; a desire to always know more; a love of problem solving, modeling and critical thinking; and sustained interest in research and investigations - from that bug under the rock at age six, to the infrared spectrum of stars. A variety of questions in the interviews led to an expression of these desires and values for each of the women. This passion for things of the mind seemed connected to the calling that each woman had for work in a science field. Dr. Hawkins summed this up when she said,

I think that’s what I like the best about the field, the occupation or whatever it is I’ve chosen in my life, you know, spend fifty or sixty hours a week here or
whatever and every week I just learn so many new things and I just love keeping my mind active and being challenged again.

Similar comments were offered by the other women as well.

I think it’s a terrific career. Certainly have no regrets. I absolutely love it and I do it to help other people and encourage them to go into science and into medicine.

I love it. I love doing the science too but the science is fun too because I get to work with other people.

So, I really liked modeling and design and I had the freedom to do that in database systems but also a very practical outcome from that. So I did fall in love with that but that would have been more graduate school.

This love for the intellect includes a love for school and many subjects not always just science or math. These women used words like, “fun”, “enjoyed”, “wonderful”, “loved”, “joy”, “beauty” and “passionate” in describing their experiences in school.

They had positive memories of school and usually enjoyed being a student. These comments are contrary to the notion of the chili classroom climate for most female science students (Kahle, et.al., 1993; Rosser, 1990; Roychoudhury, et. al., 1995; Sandler, et.al., 1996). They liked learning and making good grades. Dr. Kendall shares her love of learning in and out of school.

Also, I had a little, they wouldn’t let me have a chemistry set, they were afraid I’d blow something up I think, but I had a biology kit, a microscope and I was always looking at that. And as far as homework, I loved my math homework. I would come home and do my math homework just for fun.

They were motivated to want to know more about things and so enjoyed school projects that required research and inquiry. They also expressed an interest in other subjects like philosophy, history, literature, art, and music. They had a passion for learning just for the sake of learning.
Some of them talked about struggling with choosing an area of study because of this varied interest. This love of a variety of academic subjects and learning just for the sake of learning carried over into their professional pursuits. Dr. Grant’s areas of study and research have included math, physiology, anatomy, and evolution. She speaks passionately about being drawn to so many different areas;

I got degrees in three different fields. My PhD thesis was a mathematical model of diversity over evolutionary large time called diversity in Cenozoic mammals. My Master’s thesis was on feeding in hyraxes and how they move food around in their mouth and how evidence for neural control. The two streams of work, and I’ve got two whole entirely separate streams of research, which is partly what drives me crazy right now. One is that I work on the neurophysiology of feeding, mostly it’s been in infants and how infants swallow. She talks about the beauty of geometry and how there are a “gazillion other things” she wants to do. This interest in a variety of areas is also related to an awareness of the integration of subjects, how many of these things are interconnected. Using math for modeling in biology, and connecting evolution and anatomy in research are examples of ways in which Dr. Grant has connected various subjects in her research and study.

The idea of learning for the sake of learning seemed supported by two fundamental desires; the desire for discovery driven by a persistent sense of curiosity and the desire to think critically, solve problems and create models. Dr. Harris says a key motivator for her in science is that there are “constantly questions to ask...”. In a variety of ways each woman talked about these underlying values in choosing science as a field in general and their areas of research more specifically. Dr. Dunn expressed this in choosing her area of research in computer engineering;

At some point it just became joy to work on this material. I enjoy it and I feel a real thrill when I complete a theorem or come up with a good idea for doing something or discovering something somebody else hasn’t seen before.
In protesting the stereotype that science is just about facts, Dr. Kramer connects the ideas of problem solving and creativity with building on previous knowledge. Her own philosophy about being a scientist is built on the importance of discovery and problem solving.

The ability to stretch that is what makes scientists I guess. Just to say, okay, we did this, now what if this, what if that and then to solve, basically ask your own questions and solve them and that’s creativity in science. You know, and I guess you can see that in other areas like arts where, you know, basically you build on what’s come before, you master what’s come before and then you move on and create your own thing and, you know, and humanity says something about life and then in physics it says something about the universe.

This seems consistent with Polyani’s notion of the art of scientific research requiring personal knowledge, intellectual passion, faith, intuition and tacit understanding (Jacobs, 2000).

**Passion for the Profession**

Each woman seemed driven to bring something new to science and build upon that base of knowledge. For some this meant working cutting edge fields where little work had been done. For others it meant applying techniques or combining ideas in new ways. Dr. Kramer did her doctoral research on magnetic molecules which were actually hypothetical and had never been observed. Dr. Harris chose the field of immunology and rheumatic disease when it was just beginning. She saw lots of unanswered questions in this field and people suffering from disease as a result of this lack of knowledge.

There were very few answers and certainly no cures and certainly no information about the causes of these diseases so that’s what kind of triggered my interest.

Dr. Hawkins wanted to investigate the stars using techniques other people weren’t using or hadn’t yet seen the value of. She speaks of being motivated by always trying new things and connects that with her love and quest for knowledge at a younger age.
And every two or three years, I can’t stand to do anything more than once, I just want to do something completely different and other people do the same thing over and over again. They develop some kind of a program or some kind of an analysis technique and they just keep doing one star after another star for decades, you know what I mean? That just sounds so boring like I know how to do this really well and I’ll just keep doing it, which is good, I mean, obviously they’re getting the science out but it’s not my deal. I tend to like to do new things all the time and this goes back to how I’d look in the world book encyclopedia and I end up looked at ten different things I wasn’t supposed to look at.

Dr. Grant has combined work in anatomy and neurophysiology to develop research projects on muscular dystrophy, cleft palate and Parkinson’s Disease. She has taken her diverse set of interests and found connections that help look at problems in a multidimensional way.

Each woman expressed how much she loved science and her chosen profession. They spoke passionately about being able to do something they love and get paid for it. In some way they were each able to take something they had loved as children and young adults, areas of study that they always enjoyed and turn them into careers that they loved as well. There was a connection between an innate passion for knowledge in general and scientific research specifically to who they had become as scientists. This is expressed by Dr. Grant’s when asked if any specific experiences kept her going in science;

Partly just that I really wanted this, that it was important, the sense of that I was not going to fail at this. The love of the outdoor world, there’s a big chunk of just loving that and the natural world and the beauty, the overwhelming beauty, of the world, the mathematical order that you see out there and the same reasons I love Bach. The same reasons most computer programmers love Bach. There is an organization and a beauty to the structure and that is what I see in my data.

Her sense of passion for natural order and the beauty of the world are fundamental to her desire to become a scientist. Trwaek’s (1988) male physicist in Beamtimes and Lifetimes expresses a deep desire to know nature. She uses the metaphor of a love affair and equates the physicist’s passion for nature with a female love object. However, this is
not a common image one gets of male scientists and in Traweek’s case she could easily be arguing for the way in which scientists objectify the subject - the passion notwithstanding.

**Ethic of Care**

*Responsibility to Others and the World*

In 1982, Carol Gilligan wrote that a woman’s moral development centers on the importance of relationship and need to care for others. Women have a tendency to feel a sense of responsibility for the world around them. This is influenced by social forces and how they interact with gender. As connected knowers women find agency in their relationship with others (Belenky et.al., 1997). Each of the woman interviewed expressed some way in which they were motivated by an “ethic of care”. This refers to a sense responsibility towards using science for the greater good. In different ways they were motivated to help others or fill a need they saw in society by applying their understanding and skill in science. This theme includes ways in which the women wanted to use science to solve medical problems, protect the environment, teach and mentor others, make science more accessible to others, help people manage information in a variety of business and educational settings, and advance scientific knowledge.

Some feminist critiques of science (Kleinman, 1998; Rosser, 1990;) say science is less accessible or appealing to women because of the type of projects it takes on, for example those consistent with military and political agendas. The experience of these women indicates that this was not an issue for them or they determined agendas that were more consistent with their own values. Eisenhart and Finkel (1998) describe women in places outside mainstream academia, seeking to impact similar social and cultural issues. The
women in this study are all deeply entrenched in academia and still successfully working towards the fulfillment of societal needs.

This ethic of care is consistent with the notion that making science more personally relevant and meaningful makes it more appealing and accessible to potential scientists. Nel Noddings (2003) also writes about a duty to care and its importance in education. Some educators propose pedagogy that is directed to a more personal experience of science (Barton, 1997). For these women, science has became a personal pursuit because they have seen how they can use science to support their own beliefs about what the world needs to be a better place.

Dr. Harris cites the fact that there were medical problems in her family as a reason she went into science. She also remembered going to school with a young classmate who suffered from epilepsy and seeing a friend who died in a tent fire at a very young age. As she continued to study medicine and work with patients she saw many people suffering from diseases for which there was no cure. She wanted to be a part of the solution for that.

...why you get into the investigation is because there are whole rows of patients in front of you that you don’t have an answer for and you don’t have a cure for their diseases. That’s what it really comes down to that drives all of us here and this is particularly true for this logic of rheumatic diseases because immunology is actually a relatively new science.

Dr. Harris joined a university research program that she knew was in a cutting edge field to address rheumatic diseases. She knew she was getting into an area that could potentially help find cures for “hundreds of diseases” and this was a motivating factor for her.

One of the new diseases is rheumatoid arthritis, which is a major disorder to two or three million people in the United States, a severe crippling system disease.
And more recently the advances in immunology have allowed us to understand what it is in the immune system that’s destroying people’s joints. In the last few years this information has allowed us and several big research companies to develop new treatments.

She continued to participate in this research for which she has won national and international acclaim and also maintained a patient load at the university hospital where she worked.

Dr. Grant has also worked in medical research and has combined her background in evolutionary biology, neurophysiology and anatomy to study mechanisms of swallowing in an effort to help solve developmental problems in infants. She has also worked on determining the effect of malnutrition on growth and developing models of how clef palates form. Dr. Smith and Dr. Kendall were motivated to do environmental work. They each related the growth of environmental issues in the 70’s and to their research interests. Dr. Smith explained how her role as a mother underscored her concerns for the environment.

And then I had my child and after a little bit of time the world started to look very scary and dangerous to me, just in terms of how you live and where you live and what you’re exposed to and I think the direction of the type of science I do at some point I had decisions I could have done, natural plant chemistry or natural reactions in ecology but I decided it was more important to do environmental work.

Dr. Kendall recalled a field trip to the EPA as a significant event for her. That experience combined with an undergraduate research project on water pollution and the media coverage of environmental issues had a real impact on her. She wanted to work in the area of water treatment and water pollution as a result of these experiences. Furthermore, she realized that as an engineer she could be a part of the solution or a part of the problem. She chose the former.
I wanted to be on the side of the equation that helped the situation rather than created more pollution, which a lot of chemical engineers design bigger and better chemical plants without the thought of how to balance that with nature.

For Dr. Dunn, helping others comes in the form of managing information and data. She spoke passionately about the joy she gets from sitting down with someone ad helping them design a database system that makes the information accessible and manageable.

I really enjoy talking to someone who would like to have a database system. They have an organizational need to have this data resident in some permanent ways so they can extract it and make decisions about it or just keep the information for historical purposes or whatever. I really like sitting down with somebody and figuring out what it is they need to have stored and I draw pictures and there are actual conceptual design techniques for putting these picture together and representing the information and then there are algorithms to translate the pictures into a physical representation in a database system. Then there are techniques for extracting the information and what you don’t want is the burden to be on the user who writes the queries. You just want them to select the information that they want and there’s an automatic system called a query optimizer that transforms the query to run in the most efficient way possible so that they get their answer fast but you don’t want that burden to be on the user to figure out the best way to write the query when you can have it automatically done.

She expresses an appreciation for the needs of the user in terms of managing the database as well ways to make it as efficient as possible. Furthermore, Dr. Dunn expresses the importance of taking theory and making it practical and useful. In this way, she attempts to make science or at least the uses of science more accessible to others, in particular those, such as an end user, who are dependent on the system but not necessarily educated as to how it works. Dr. Kramer also expressed an appreciation for making science more practical to make it more easily understood. She attempted to apply this to a course she taught in physics.

When I was at Harvard I taught a particle physics course and I taught it from, well you couldn’t call it hands on because, you know, particles aren’t really hands on,
but it was a much more practical standpoint and less formal than a lot of other courses that are taught there.

Dr. Hawkins also spoke of making science more accessible to others not so much in this sense of application of theory, but in terms of non scientists having some basic knowledge about science. In her teaching she was motivated to make her students more scientifically literate so that they might understand stories of science in the news and perhaps become more interested or excited about science.

I try to use that with astronomy when I teach as I hope that the students learn just enough astronomy in class that when they hear a story on the news about the Hubble space telescope their ears perk up...And it makes them listen and be interested in science and I think that’s kind of a neat thing to get them not to become scientists, but just to say that science is actually kind of interesting....now I understand why those eclipses are or now I understand what they mean by the big bang. I tell them frequently in my class “You’re going to be a popular person at most parties because you can go on and on about things like, you know, I can tell you about relativity if you want to learn about it.”...just that kind of thing and it’s not super useful knowledge...but it’s fun to know and I think it challenges the students to think quantitatively. You know, a lot of them...just want to think that science is just memorizing the right answer....Somewhere there’s a book that doesn’t have the answer in it and someone’s got to figure that out and it’s going to be a scientist and you can do the same thing.

Here she expresses not only her desire that her students get excited about science but that they see it as more than just an accumulation of facts, that they appreciate the need to think critically and that they perhaps see themselves as being able think like a scientist. Dr. Hawkins spoke of trying to dispel other misconceptions about science as well. For example, the fact that science theory is dynamic and new evidence can cause a theory to evolve or be dismissed. These were important areas she tried to cover in her classes with science and non science students. In this way Dr. Hawkins makes evident her desire to help others through her science teaching.
Teaching Others

Making a contribution through teaching and mentoring others was also valued by the other women scientists. Although they are all researchers, each also had responsibility for teaching at the university and considered this an important part of their role as a scientist. Dr. Dunn spoke of the ways in which she brings research into her undergraduate classes so that they can see science theory at work. She also said she thought her greatest impact had been on training students. Dr. Harris said she got the most satisfaction from training the students with whom she had worked. Dr. Smith spoke of the joy of seeing students years after she had taught them and hearing that she had changed their lives. For Dr. Hawkins teaching science was one way to show the social nature of the work of scientists and that it is anything but an impersonal and socially isolated career.

Mentoring others as an advisor and teacher was an important role for these women. They were committed to helping students understand more about how they could become scientists. Dr. Kendall described a recent time when she started to question her career in science and what she really wanted. She concluded that advising and mentoring others were central to her work as a scientist.

But to be able to help people in an even more direct way rather than cleaning up water. It had a certain appeal to me. I actually went through some more career counseling and testing and kind of came to maybe really what I am isn’t so much a pure scientist, just somebody who likes to mentor and teach and was trained in science.

These women also saw themselves as visual examples of what a female scientists looks like and that perhaps this might assist a students to see herself as a scientist. They could mentor by example.
And so I think it helps to model what a woman engineer is like, I model it a little differently from Ming Ming and I’m sure I’m a little different than Cynthia so I think it’s helpful to have more examples.

Well, when I go out and talk to kids at schools, in high schools, elementary schools, middle schools, whatever, I figure half of what I’m doing there is just saying somebody who looks like me can do this work and isn’t it cool. So you get that double bonus of not only am I doing something I really like but look, I look like you.

This has been shown to be a powerful way to influence women to consider science careers through helping to build their own self concept as a scientist (Brickhouse, 2001; Zachs, 1999). The ethic of care extended beyond applying science to solve societal problems, but also supporting others in the pursuit of science through teaching and mentoring.

Self Efficacy and Agency

Belief about Identity
Successful women scientists have often overcome significant barriers to realize their goals as scientists (Harding, 1991; Rosser, 1990; Rossiter, 1982; Scheibinger, 1989). Biographies of successful women scientists reveal a sense of agency in these women that indicated their success was due to a combination of talent, internal drive and belief regardless of the obstacles they faced as women in a predominantly male field (Keller, 1983; Scheibinger, 1989; Shepherd, 1993). Yet others cite these barriers as the very reason women are precluded from science fields (Eisenhart and Finkel, 1998; Rosser, 1990). If in fact women are made to believe they cannot do science, these contemporary women scientists ignored that message or found ways to overcome it. If what it means to be a woman and what it means to be a scientist in society are often at odds
(Brickhouse, 2001; Harding, 1991; Klienman, 1998) these women have found ways to negotiate that contradiction perhaps through their own self efficacy and agency.

Each of the women in this study painted a picture of themselves as independent, confident, self assured, accomplished and self fulfilled. It was obvious that they were intelligent, energetic and driven and, as a result, productive in their careers. They appeared to have high self efficacy that resulted in a sense of agency that was central to their pursuit of science and the success they have enjoyed in the field. Self efficacy is considered one’s belief about one’s own capabilities to perform a task or accomplish a goal (Zimmerman, 2000). Central to this self efficacy was the underlying assumption that they could be scientists regardless of any implications to the contrary.

I believe I could do science under any circumstances.

So I know that there are people that are not meant to be scientists but I don’t think I ever thought I wasn’t supposed to be.

I guess I’ve defined scientist as what I am and I’m not redefining me. I’m redefining what it is to be a scientist is to be what I am.

The bottom line is they could see themselves as scientists. Whatever messages are out there that women do not do science; those messages did not seem to get through to these women or they were able to redefine that image of a scientist for themselves. Dr. Kendall acknowledged the male stereotype of an engineer and talked about trying to fit with the “caricature of a typical engineer”. When asked about the significant areas of influence in her decision to become a scientist she replied:

Coming to terms with the character, caricature of a typical engineer, didn’t have to fit...you know, that I could find a way to use my talents and find work. It was my value system within the technical field. And that’s just a shift of paradigm on my own part. Really, none of the world changed around me.
It is worth noting that both her father and grandmother and were engineers (her grandmother was trained but did not work in the field) and that she was exposed to professionals in the field from a young age. But it is also significant that she attributes her vision of an engineer to her own belief in her talents and her internal values.

*Family and Agency*

Belenky et.al. (1997) found that the relationship women have with their parents is significant to the way they develop as knowers and their ability to relate to themselves and others. As discussed earlier, the support of family and a nurturing family environment was seen as influential by many of these women. This family support seemed central to the strong self efficacy of many of these women. Dr. Dunn attributed positive beliefs about herself to the support and love of her family and related this to her belief about being a scientist.

I think probably the nurturing family environment also contributed and I had good self-esteem. I never doubted that I could do what I was doing and it never even crossed my mind to doubt because I had such a loving environment at home.

Parents have been found to have a significant effect on the successful pursuit of science careers by girls (Clewell and Campbell, 2002; Ethington, 1992; Farenga and Joyce, 1999). For some of the women in this study, their parents sent them the message that they could be whatever they wanted to be. Some parents were explicit in the message they sent to their daughters that girls can do science despite any societal messages to the contrary. Dr. Grant’s mother told her pointedly that people might treat her badly, but that she could still be a scientist. The high value placed on getting an education and positive affirmation from their parents about being a good student were important factors. The feedback from their parents often reinforced that they were talented students and that was
a good thing. Dr. Kramer cited the encouragement throughout her childhood as a
significant factor in choosing science as a profession. There was an underlying
assumption that she would and could be a scientist. Dr. Smith related how her family
saw her as the “achiever”. They recognized and encouraged her talent in school that
made her stand out even amongst her own siblings. Recognition as a good student was
important to these women and something they generally believed about themselves.

**Belief in Ability**

Each of these women also saw themselves as excellent students at some point in
their education (for most it was throughout) and placed a high value on that, not just in
the sciences but in other fields as well. Even if they saw themselves as weaker students
in their early schooling, they eventually took some science related class in which they
excelled and were affirmed in their ability. Several cited high class rankings, straight
“A’s”, easy comprehension of material, school awards, being the best in a subject and
competing well with other students as examples of their academic accomplishment.
Dr. Dunn connected her abilities as a student with access and opportunity;

> I guess because I was always such a good student I never thought any of those
doors were closed to me because I liked the material and I could do the material.
You know, I’d get my test back and they’re A’s. It never occurred to me that I
couldn’t do it.

Their ability as excellent students was constantly reinforced. They were selected for
special testing, put on accelerated tracks, received academic awards, chosen for special
programs, received scholarship offers and admissions to highly competitive schools.
Some noted how teachers and professors would acknowledge their work and encourage
them, some times when they did not see their own ability. For each woman it was
significant that at some point they realized their science ability and connected this with

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their life goals. Moreover, many noted how they recognized that they had a talent in a science or math class that others did not seem to have. This made them feel like they stood out or had something special that they should take advantage of. Dr. Hawkins realized her ability in physics was something special.

But also, so many kids thought it was such a big deal and it was so hard, you know, and it wasn’t that hard for me. And I remember thinking, ‘this has got to be worth something, right?’ You know that you can do something that other people seem to think it’s really hard to do.

This realization combined with the encouragement of teachers sent her in the direction of astrophysics even though she discovered her ability and interest in science when working in a nursing home. Others talked about how they connected their skill in science or math with their interests in those areas. That skill would be reinforced as they moved through the educational levels and into their professional and academic appointments sometimes because they saw this special ability they had. Dr. Hawkins realized her ability to stay with the tougher classes when others were not, meant something about where she was headed.

There were fewer and fewer people in my class and it was becoming a big deal that kids couldn’t, you know, so taking a more advanced chemistry courses and math, taking calculus and that kind of stuff, I realized that I was still hanging strong on this. I was still a top student and I kept going, ‘well, where is this going to go?’

Some authors cite the loss of women scientists as they progress through the educational levels (CAWMSET, 2000; Wilson, 2004). These women were able to overcome whatever issues cause this lack of persistence and it appears this self efficacy and sense of agency that was supported by many factors may be central to this. While they recognized their own special ability in science though, and saw themselves as good students some were surprised at their own success at times. Dr. Kramer did not expect to
get eight offers for faculty position including one at an Ivy League school, even though she as an excellent student from an Ivy League school.

*Facing Challenges to Ability*

At some point each woman faced a challenge to her academic ability. This was often in their undergraduate or graduate program where she might get lower grades than expected, or be challenged by material that for the first time didn’t come easily to her. This may have sent them in a different direction in science but these experiences were never deterrents to the progress of these women as scientists. Dr. Smith spoke of the way in which a low grade made her think that perhaps her talents were elsewhere in science than that particular class—as if it were almost a relief to perhaps get that direction.

You’re not getting an A. That means you are probably all those things you say you are and you’ve had that experience but it’s a good thing to realize that some other things are out of element, you know, you have to do other things. So, it’s good to finally get to the point where you have to feel like, oh my gosh, I may not be able to do this.

Others referred to similar experiences and did not seem daunted but rather determined to make it work or find the right place for their science. This is one example of the way in which their sense of agency helped them to overcome any struggles or barriers.

There were other struggles and barriers as well, such as problems with an advisor, periods of self doubt, lack of support, personal issues, relocating far from home at a young age, criticism from others, and minority status as a woman. Some of the woman also spoke of hardships their parents had to overcome. These stories each contributed to an overall sense that persistence and survival were fundamental qualities for these women. Several had gotten messages from their mothers or another woman in their life that it was important to be independent and not depend on someone else. This sense of
independence was referred to by each of these women. Listening to them one gets the sense that they took responsibility for themselves and this gave them a great sense of agency that was helpful in persisting in the field of science. It was a field that they often described as requiring lots of hard work and commitment. But several would describe themselves as “stubborn”, “survivors”, “committed” and “independent minded.” Dr. Kramer declared that her stubbornness got her through. She had to be stubborn to stay in physics. When she experienced any self doubt or when she acknowledged the low number of women in her physics classes, she said one had to be stubborn and stick with it.

In some ways, these women would say they had not faced barriers. External barriers did not matter, because what mattered was the internal drive and initiative. True barriers would be internal problems. Dr. Grant describes it this way,

But, you know, for barriers and I understand that lots of people think there are lots of barriers for women...but I guess I just didn’t perceive them as barriers. I don’t perceive that there were lots of barriers. I, you know, if there were barriers they were things inside of me and not external world things and all the little petty flaws inside each of us that we struggle with to make ourselves work harder, make ourselves follow through on projects, make ourselves organized.

Here Dr. Grant refers the importance of internal drive and motivation and others did as well. These qualities were expressed directly or indirectly in the discussions with these women. Science takes hard work and commitment and the drive to do this has to come from inside. Dr. Kramer recognized one of her weaknesses was public speaking and described how she was determined to work hard at this and overcome it. Overcoming any obstacles had to be connected to a real desire and for these women it was clear it was the desire to learn, discover, solve and teach. Dr. Grant acknowledges the support of others and the importance of affirmation.
A large part is just internal drive and a large part is having met people who counteracted. Random bad things are going to come at you at life and I think all the good people sort of helped counteract that not just professionally in terms of letters but just sort of internally in terms of reinforcing what I believed I could do.

Dr. Hawkins describes the support of faculty in her program in reinforcing that she was a good student and needed to stay that way.

So they were pushing me to make sure I got those good grades and telling me how important it was but also never saying you’re not good enough, just saying you are and I think they could tell because of my drive and everything else that I would be successful at it but they said it’s very important you continue to get very good grades in your physics courses so you get into the top programs.

These women took responsibility for any obstacles or barriers they had to overcome and attributed their success in doing so to a strong sense of agency. This agency resulted from a strong science ability and internal drive. It was also attributed to the support and encouragement of others, specifically parents, but also teachers, professors and mentors.

Each woman acknowledged in some way the amount of extra work and effort required to be a scientist. The way these women negotiated this requirement was evidence of their sense of agency. Science is not a forty hour per week endeavor, but often requires many late hours in the lab and a great deal of concentration. It required staying as long as it took to get the work done. Scientific research is very “consuming” and “not a nine to five event” and each woman demonstrated their acknowledgement of that fact and spoke in some way of how they were committed to that extra work and effort as part of their success in science. When asked about the qualities of a successful scientist several of the women responded in some way about the need for a lot of energy, enthusiasm and commitment to get things done. Dr. Harris spoke of this in her response.

You better have lots of energy if you’re in this business, to be perfectly honest... because there’s really an awful lot to do. Patient care, investigation, keeping up with your discipline, teaching, all of these really require a lot of energy. If you’re
a six-hour day person forget this career I can tell you that, okay? So that’s number one I guess, one has the physical ability to keep going at it...to be enthusiastic and energetic.

Related to this level of commitment is the fact that science also requires a lot of sacrifice for others aspects of one’s life.

Reconciling Family and Professional Goals

Each woman spoke of the ways in which personal and professional goals are often in conflict in science. Bozeman (2004) discusses how this issue of conflict exists and has not been addressed adequately in academia. For example, women scientists are often faced with making choices between having a family and staying on a tenure track. The fact that there are fewer women scientists in academia (Wilson, 2004) may reflect the fact that women avoid such positions due to the inability to balance scientific research and family obligations. Dr. Dunn referred to this article in her comments

And what they said was that women self select or for the large majority of women they self select and don’t even interview at the research universities because they know what kind of profile is expected and its long hours and sacrifice of family and home life.

Even though she held a university position, she could relate personally to this point. This conflict between personal and professional goals was discussed by each of the women in this study in the context of the choices they made about their personal and professional lives. Some had chosen to have families and felt this was necessarily delayed by their science careers. Those women also acknowledged that they were aware they would sacrifice some aspects of their science success to do this. Dr. Dunn remembered crying in her office the day she knew she was going to have a baby thinking she would probably never see another merit increase as a science professor. Other women spoke of not having children in lieu of their commitment to their profession. Dr.
Kramer said she had to scale back her research to accommodate the needs of her family. Dr. Grant suggested that the women who had children in this career did not achieve at the same level as those who do. They were also aware that this issue did not exist for the men in their field. Dr. Dunn observed that men hired after her were starting to pass her up in their progress towards full professorship. Dr. Hawkins said she got the message that women didn’t need to accomplish as much as men because they could always just choose to stay home and raise a family.

You know, comments have been made sort of suggesting that it’s not that important that I succeed because of course I can always just get married and stay home it’s not that important for me where for a man of course he have to have his career, what else is he going to do, he can’t stay home those kind of really subtle things sort of suggest that it’s not that important that you work that hard.

Regardless of the choices made by each woman, it was clear that this conflict between personal and professional goals was a significant aspect of their work as women scientists and not one that most of their male colleagues had to deal with. In this way, gender played a role in the experience these women had in science. In general this was viewed as a negative impact, and one way in which women are at a disadvantage compared to their male colleagues. However, each woman seemed satisfied with the choice she had made and seemed empowered to negotiate this conflict in a way that supported her choice. This is evidence of strong self efficacy and acting with the agency that provides.

*Being in the Minority*

A common experience for all of these women was that at some point in their careers they were in a small minority of women in a male dominated department. This might seem a challenge to a woman’s sense of agency but did not seem to be the case with these women. This would be considered a significant obstacle for many, even boys
(Monastersky, 2005) and is viewed as one of the reasons there are not more women in some science fields (Eisenhart and Finkel, 1998, Lazarus, et.al, 2002; Wilson, 2004). The women scientists in this study obviously did not let this be a barrier to their science achievement even though they spoke of this experience in many ways. Most of them spoke of it as a challenge that they welcomed to some extent, because it made them stand out. Some enjoyed being the only women or girl in the class. Others felt they were noticed or stood out because they were one of small number if not the only women in the class. This is not to say there were not incidents in which they felt their gender was a disadvantage. But each woman found some way to negotiate that and often seemed to put these experiences with gender outside their own experience. This “externalizing” of the experience may have been one way they were able to overcome any barriers presented by their gender and status as a minority.

Some of the negative experiences with gender were discussed in the section on personal experience with science. This included dealing with the male image of science, being treated differently as female students, having lower expectations as women and getting messages that women cannot do science as well as men. The way gender seems to impact self efficacy and a sense of agency lies in the fact that that while these women acknowledged these conflicts and barriers, they did not deter them from science. This may be due to their strong sense of agency and also seems related to the fact that they often separated these gender experiences from themselves or simply considered them challenges to overcome. Dr. Grant explains it this way when discussing her experience as the only woman in a math class...

You know, it was sort of a source of pride as much as anything and it was more of an issue that I just didn’t look at because to me it felt like the reason I’m not doing
Well is because of me. I’m not good enough. I’m not a good enough mathematician, you know, and if I’m not doing well in the other things it’s because I’m not working hard enough. It was all very internal. It was not that the external world. I think my philosophy in general suggests that that’s legitimate, you know, but there may have been things but, you know, suck it up and get over it because if you want to do this to expect society to bail you out is illegitimate.

These women seem to take a sense of pride and ownership in being a minority in their field and that sense of responsibility means it is up to them to overcome any barriers their status might present. Perhaps this is one of the most significant ways in which self efficacy and agency influence the ability for women to become scientists.

Marginally vs. Belonging

Marginalizing Experience

The life stories of the women scientists in this study seems contradictory at times and antithetical to the notion of being a women in science. They speak of ways in which they were a minority in the field as students and as professionals. They speak of examples in which they felt singled out and at a disadvantage because of their gender. Yet they also speak of ways in which they were participating members of the scientific community that was often a source of support and encouragement. Brickhouse, et.al. (2000) examined the way in which young women form science identities and the importance of being able to relate to the community of practice. Often this community is not accessible to young women. Women in science are often marginalized in the experiences with science (Eisenhart and Finkel, 1998; Rosser, 1990) and in particular in the areas in which they practice science. In many ways, women have been excluded from the practice of science through the interplay of gender roles and the image of science (Clewell and Campbell, 2002; Eisenhart and Finkel, 1998;). Eisenhart and Finkel describe women scientists in what they call the “heretical” spaces of the sciences –areas
that are often overlooked by mainstream science and academia. While they may practice science, they are marginalized in that experience. The women in this study would not be considered marginalized in that same way, since they are practicing scientists at a Research I University. However, one might question if they are marginalized in their experiences in academia. Furthermore, it might be possible to interpret their minority status as women in these positions as marginalizing. Wilson (2004) and Lazarus, et. al., (2002) speak of ways in which women are isolated in the scientific community because they are often in the minority. However, based on the interviews with these women, they would likely not agree. Many of them saw their position as the only woman or one of the few women in their programs as a special status of which they could be proud. Dr. Smith spoke of being special as one of a few women in the field and also as compared to other women and Dr. Kramer speaks of being above others,

"It’s kind of interesting because, you know, you want to be somebody special. It’s kind of an interesting way to be somebody special in a completely different way than I think would appeal to most women.

One of the things that I’ve seen that is fairly common is, from the women I’ve talked to, is the real strong sense of themselves as students of science in high school, grade school, kind of standing above other people.

On the other hand they each speak of the role of community in their ongoing development as scientists. In spite of their minority status and numerous examples of discrimination, these stories give a much stronger feeling of belonging than one of being marginalized.

A Sense of Belonging

Each of the women talked about people, other than family members who supported them along the way and gave them encouragement. As previously discussed,
this included teachers and professors, but also peers and coworkers. Some of the women talked about groups they associated with who had similar interests and talents. These could be other women and often included male peers as well. They might students who liked studying in general or a similar science area. Dr. Grant spoke of her excitement about join a group of “like minded nerds” in college. Her peers in college were a very significant group for her.

What I can remember is having very good groups of peers, some in science. I mean, I loved geology in college; I went on lots of field trips. There were a couple of graduate students who I really got to be friends with who were very good to me and then in graduate school there were these very good groups of peers that were almost as important to me as the faculty were.... I can sit here and I can remember the problems but what I remember is a group of people. There are people from grad school who I still, even though their science is very different, who I’m still in contact with.

Dr. Harris talked about the significance to her of being with like minded people as she considered her career options. She felt it was a great support system to be with people who think in the same way. For some their peer group in high school was a group that shared in the same level of academic success and many were discussing possible careers in science. Dr. Kendall spoke of the importance of a group of girls in high school that shared the same interests and excelled in similar subject areas. They were the top four students in the school.

Dr. Hawkins pointed out that the nurses she worked with in the summer after her senior year were influential in encouraging her to go into science. They affirmed her ability in that area. Dr. Smith talked about getting encouraged by other people one encounters...

I think you get encouraged by the people....People around you kind of influence what you see as, not just possible, but what you think you ought to be doing, you know, their expectation.
Dr. Dunn said she was more “peer guided” than self guided. She also offered an interesting perspective about the ability to communicate on some special level with other like minded scientists.

I had one PhD student that I had extremely good rapport with like that and maybe a couple masters students. It’s a unique experience. Just to have a good idea and to be able to get somebody to understand it in a minimal amount of words and communication and they get excited, they latch onto it, it grows, you bounce it back and forth and it becomes something from almost nothing or just a little tiny seed.

She went on to say that a lot of people don’t realize the level of social interaction in being a scientist.

This interaction was evident in the various research groups and collaborations many of these women have experienced. Their stories would speak to the social nature of science in the sense that it requires interaction and collaboration with others. Connecting with the scientific community was obviously important in developing one’s profession. This was more than just networking to find jobs, but involved brainstorming, research, collaborations, information sharing and of course teaching and advising. Dr. Kramer spoke of the significance of collaborations in physics research and made some of her decisions based on the size of these research groups. She encouraged young women scientists to work with others.

...encourage formation of, I don’t even know if you would call them support groups, but groups that educate young women and all the things that can happen that really are part of a larger phenomenon and not just, you know, your own lack of confidence. I don’t quite know how to do it because young women are, you know, really do tend to think that they can do it on their own and that it’s just an individual thing.
Dr. Dunn talked about how important the sense of community was to her in staying in her major. She got support from people she knew were succeeding.

We knew there was going to be a meteor shower and so we piled into cars and went out into the countryside and we set up lawn chairs and we were laying in the road looking at the meteor shower. It was really fun. I guess that was kind of scientific and kind of social but we would do something like that. But having a community, I think, in both my undergraduate years and my graduate years was very helpful.

Dr. Kendall emphasized the importance of working with a broad range of people to be able to see research questions from different angles. Her work in research groups taught her the importance of collaboration and cooperation in science. This is interesting given the fact that science is often seen as a very competitive endeavor and for that reason less appealing to women in some ways. She also observed that her work in research often made her lose sight of the fact that she was the only woman.

These experiences with peers, in research groups and collaborations speak to a sense of belonging that each of these women experienced in their science careers. Even when they spoke of being alone in a field of mostly men, they were able to identify some support system that kept them from being marginalized. They also participate in research projects recognized by the community of scholars as supported by their success in publication. Some chose research projects that were not in the mainstream, but more in the cutting edge of their field. In each case the woman chose this intentionally as a way to have an impact on what she considered to be a significant problem. When speaking of their experience as minorities in the field most did not give voice to being marginalized. They also shared ways in which they see access for women changing even though their experience is still to remain in the minority.
CHAPTER 5

Discussion

Introduction

Based on their oral histories, the lived experiences of the seven women scientists interviewed for this study offer insight into the ways women can access and pursue science careers. Their individual and collective experiences help paint an overall picture of what a successful woman in science looks like. The factors and influences that lead them to their careers speak to the ways in which they were able to become successful scientists and overcome any barriers to do that. In this discussion, the patterns that have emerged from their stories will be evaluated by relating their experiences to the feminist critique of science, the role of gender in pursuing a science career and the construct of an “ideal type” as an exemplar for how women can pursue science. In closing, this study will present some assertions about pursuing science as woman in the present day that might be useful to consider for further study.

Relating to the Feminist Critique

These seven stories of women practicing science offer the opportunity to consider elements of the feminist critique of science and determine ways in which it applies to real experience. In particular, these women’s experience can validate or call into question four aspects of this critique; the extent to which it is a male enterprise (Bleier, 1986; Haraway, 1988; Harding, 1991; Keller, 1985; Kleinman, 1998), the social context of science (Harding, 1991; Keller, 1985; Rosser, 1990; Schiebinger, 1989) the relevance of standpoint theory (Haraway, 1988; Harding, 1986; Harstock, 1983) and the proposition that women may do science differently (Belenky, et.al., 1997; Harding, 1998b).
From these stories it is obvious that science is still a predominantly male profession, not only in the sense that each of these women were in a minority because of their gender but also because of experiences they encountered as a minority. However, the picture they paint is not necessarily one of exclusion because of that male nature. Obviously, they were each able to negotiate their minority status and most saw this as an advantage at times. For the most part, they liked the idea of standing out as the only woman or seemed to use it to their advantage where possible. Even when this minority status created barriers they were able to find ways to overcome this. Most importantly, however, these women had little problem reconciling this male nature with their own identity as female scientists. Some would acknowledge conflicts this caused but each seemed to be able to create an image of a scientist that was very compatible with who they were as women. This seemed to be derived from experiences that started at an early age including childhood curiosity and interest, in and out of school experiences and the support of family. Early on these women got the message they could be anything they wanted and being a scientist was not questioned because they were girls. Feminist writers (Harding, 1991; Rosser, 1990; Scheibinger, 1989) often point to this identity issue as a central issue in keeping women from science. Young girls cannot see themselves as scientists, get messages that they cannot be scientists or are socialized in a way that is inconsistent with what it means to be a scientist (Brickhouse, et. al., 2000; Brickhouse, 2001; Kleinman, 1988; Mason and Kahle, 1988). This study does not refute that contention but offers examples of women who were able to overcome it or for whom it was not an issue. It suggests that this ability to identify themselves as scientists is central to their ability to become one and in that way underscores the importance of the identity
issue. Clearly, these women maintained a strong sense of identity as a scientist from an early age.

According to some elements of the critique (Bleier, 1986; Haraway, 1988; Harding, 1996; Keller, 1985) the male nature of science promotes a stereotype that to be objective it must be disconnected and dispassionate. If that is the case, these women did not present a science like that nor did this image seem to create a barrier for these women. Their passion for the field, ethic of care, and devotion to research and investigation painted a picture of a scientist who is connected and passionate. Their approach to their work is much more consistent with Keller’s (1985) idea of dynamic objectivity than the static objectivity perceived in traditional male science. As the feminist critique suggests, their research agendas were affected by the personal histories and experiences of the scientists themselves. Consistent with Polyani’s (Jacobs, 2000) idea of the scientist, these women engaged personal knowledge and intellectual passion in their pursuit of scientific truth. Their research questions arose from some personal experience and a desire to help others and solve problems. As Fee (1982) suggests they offer a more human notion of doing science and their work is consistent with Harding’s (1998) suggestion that women’s contributions have brought changes to scientific research and practice, notably an improved role in social justice, an expanded notion of objectivity and greater care and sensitivity. Their approach to their research was more connected than disconnected and reflected a personal involvement more similar to McClintock’s approach to her research than that suggested by those describing the static objectivity of a male science (Keller, 1985). This suggests different possibilities about the notion of static objectivity as central to science – science is not as disconnected from the human
experience as the feminist critique or the male image would have us believe, these women found ways to operate outside that paradigm or that woman approach science in a different way than men. Most of the subjects in this study however would not agree with the last option.

The feminist critique suggests that several barriers exist that prevent women from entering science fields. These include absence of role models, lack of mentoring, exclusion from informal networks, difference in style from white male colleagues, isolation in academics departments (CAWMSET, 2000; Clewell and Campbell, 2002), conflicts with career and family (Bozeman, 2004; Wilson, 2004) and work that is often at the margins of the scientific enterprise (Eisenhart and Finkel, 1998). These women did not experience all of these barriers and were able to negotiate those they did encounter. Role models and mentoring, especially from men, were areas of support and influence for them. This is consistent with other findings as well (Bandura et.al., 2001; Campbell and Beaudery, 1998; Kahle and Meece, 1994; Jones, Howe and Rua, 2001; Rosser, 1990; Roychoudhury, et.al., 1993; Sadker and Sadker, 1994). They certainly did not work at the margins of scientific experience. Some did note differences in style from male colleagues but did not see this as a barrier. Conflict with career and family was one area that was considered a significant barrier that for some was not easily overcome to the extent that several of the women sacrificed personal and family goals to pursue science.

These women’s stories suggest that science is a social enterprise clearly done in the context of social influences. This is reflected in the personal experiences with science, the influence of contemporary events and most importantly the influence of family. As Harding (1991) suggests these women came to science with an individual
worldview that was influenced by a combination of these factors from early childhood on. While there was significant internal motivation to be scientists there were numerous external influences that impacted that interest and helped them develop the agency they needed to accomplish this goal. Additionally, these influences from family, role models, teachers and society in general influenced choices they made about their specific interests in science and scientific research. The women scientists in this study describe science as a social endeavor. They speak of communities, research groups and collaborations. While they highlight their minority status in many of these groups, they also speak of the way in which these social structures were an important support for them. While the critique might have one believe that science as usual is an anti-social endeavor that marginalizes women, these stories point to its social nature and the way women engage in that. Nevertheless, there are still reports of women being marginalized in science (Eisenhart and Finkel, 1998; Wilson, 2004, WISELI, 2004) and these women may represent the exception more than the rule. On the other hand, they may also present examples of how to negotiate the minority status and become successful scientists who are not marginalized.

These seven stories highlight the importance of the experiential aspects of science and the influence of social factors. In this way, they are consistent with feminist standpoint theory (Haraway, 1988; Harding, 1986, Harstock, 1983). Feminist standpoint theory suggests that real science knowledge and strong objectivity (Keller, 1991) come from acknowledging the personal interactions one has with their science experiences. One’s social location matters when it comes to choosing and interpreting research problems (Haraway, 1988). This was exemplified in the way some of these women chose
their areas of research. While an objective, value free scientific method is what traditional (male) science requires, the reality is that research is embedded in personal experiences and agency that include interactions with social forces. This has to be recognized to have real objectivity in science. The research stories of these seven women would be consistent with Longino’s (2002) notion of “good science” where rationality can be context dependent. It’s okay to acknowledge the social aspects and influences in science and even better to recognize their influence on the researcher and her projects. These women had no problem doing that and acknowledged that their personal histories and a variety of social influences were significant in the development of their science careers and scientific research. This did not mean they were not able to be objective in their application of the scientific method. Their success is obvious in the success these women have in publishing research in scholarly journals. They provide meaningful examples of the way in which Harding’s (1991) strong objectivity can be achieved through the inclusion of a broader range of social experiences in this case specifically related to gender.

Connecting one’s social location with science was evident in the level of importance these women placed on personal experiences with science from a very early age. As science educators have suggested (AAUW, 1998; Barton, 1997; Darke, Clewell and Sevo, 2002; Eccleston, 1999; Fadigan and Hammerich, 2004), it was important for these women to find some personal connection with or relevance to science. Their lives offer examples of how that worked for them. The importance of practical experiences in their decisions to pursue science seemed as important to them as formal educational experience (AAUW, 1999; Fadigan and Hammerich, 2004). Similar to the children in a
study on doing science and forming identity (Reveles, Cordova and Kelly, 2004) being able to participate in a community of scientists at some level helped to promote their interest in science as well as their identity as scientists. Furthermore, it was very important to these women that their science have some practical implications or impact. They wanted to see that their research would solve some problem, offer a treatment or a cure, help others in their work or protect the environment. Their experiences with science support the effort of science educators to make science more personally relevant if it is to be effective especially for women (Barton, 1997; Brickhouse et.al., 2000; Brickhouse, 2001; Kleinman, 1998; Martin and Brouwer, 1991; Meyer, 1998; Milne, 1998; Rosser, 1990; Roychoudhury, et.al., 1993; Roychoudhury et.al.,1995; Richmond et.al., 1998). In a case study of three African American girls, Lewis and Collins (2001), found that interest in a science career is strongly motivated by the belief that their career relates to deep seated life goals. Madill, Montgomerie, Stewin, Fitzsimmons, Tovell, Armour, and Ciccocioppo (2000) also found that students were more likely to pursue science if they could relate to their own lives. These seven women’s stories attest to the importance of relating a deep understanding of what they can do with science to their own personal life mission.

One suggestion by some who critique science is that women bring a different approach or style to the practice of science (Harding, 1998a; Keller, 1985; Rosser, 1990). These women generally did not see a male versus female approach to science. They would more likely be inclined to agree with the perspective of Harding’s individual worldviews, but not a woman’s way of doing science. Nevertheless, their stories certainly create a picture of science that is more human, compassionate, socially
conscious and compelling than the traditional stereotype. If a young student is turned off by the projects of science; the dispassionate, objective approach to science; a focus on facts and memorization; subjects that are too difficult to relate to or understand, they only need spend a few minutes with any of these women to see a very different picture.

One of the most moving aspects of their stories was the sense of passion they had for their field and the research projects they had taken on. They were clearly motivated by a love of discovery and intellectual pursuit. Combined with a desire to help others or make the world a better place, this passion seemed to be a significant driving force in their pursuit of science, strong enough to overcome any number of obstacles. Combined with a strong sense of intellectual ability this created a level of self efficacy for these women that overshadowed any sense of discrimination, marginality or defeat. Whether they acquired this ethic of care and sense of passion from family influences, school experiences or support from others, it is consistent with Noddings (2003) notion of the importance of care. These women could take the place of Noddings caring teacher who loves mathematics. These women could be examples of Noddings “feminine world of subjectness” as opposed to the “masculine world of objectness”. To whatever extent the male image of science excludes the ideas of passion and caring, these women are a direct contradiction to that image. That may attest to their approach as women or call into question the reality of the male stereotype of science. Although some studies have found that boys are more interested in science to have positions of control and fame while girls are motivated by the idea of helping others (Gilligan, 1982; Jones, et.al., 2001). These women either do not operate in that male image or it is not as dispassionate and uncaring as one might expect. It is possible the answer lies in some compromise of the two. It is
hard to imagine that many of the world’s male scientists did not also have this sense of passion and care about their work. Traweek (1988) talks specifically of the passion of male physicists and the “love affair” they have with their subject. The feminist critique challenges male dominated science as dispassionate and disconnected in its static objectivity (Keller, 1985). The reality may be that scientific practice is much more passionate even for males than is generally perceived. This is not to say the male image of science does not create this stereotype. These women would agree that science is a compelling and personally fulfilling enterprise for which they have a great deal of passion. Any “male” notion to the contrary has not dissuaded them and their minority status as a female did not see to send them messages to the contrary. Clearly these women have been able to define science in terms of who they are but have wrestled with the reality of the male dominated science community in doing so. In this alone their lives can be very instructive for others.

Overall, the stories of these seven women present a picture that is both consistent with and offers some challenge to the feminist critique of science. While their stories attest to the predominance of males in science it does not necessarily create a picture of a “male” dominated science in that these women were able to create a science career for themselves that is not solely defined by the conditions of a male science. They support the critique in the way their stories seem to create an alternative to traditional notions of science. As the feminist critique suggests, gender is an important variable in the factors influencing their pursuit of science (Harding, 1996; Keller, 1985; Scheibinger, 2002). However, their stories do not all seem to suggest that gender is central to that pursuit.
The Role of Gender

The most compelling aspect of what these women had to say about the role of gender was the way in which they acknowledged that is was a factor in their scientific experience but often saw it as outside themselves. In her study of undergraduate and engineering students Wyer (2003) concludes that a person’s gender may be more important in explaining why a person leaves science than why they stay. Numerous examples of gender related discrimination ranging from treatment by teachers and male students to biased reviews of their work and accomplishments were not enough for these women to say that their gender was a significant problem or held them back. For the most part, the impact of gender was an external issue and did not impact the image these women had of themselves as scientists. To whatever extent they saw scientists as male, they still saw themselves in that identity also. They had not gotten the message that being a woman was inconsistent with being a scientist as some have suggested (Brickhouse, et. al., 2000; Brickhouse, 2001; Kleinman, 1988; Mason and Kahle, 1988) and if they did it did not keep them from pursuing this identity.

While gender may have presented some barriers it did not limit accessibility beyond what these women could overcome. One of the most significant barriers seemed to be dealing with the conflict between family and professional life. As other have suggested (Lazarus, et. al, 2002; Wilson, 2004) this was a more significant issue for women than men. Those who sacrificed family goals (ie. delayed childbearing) acknowledged the necessity of this to their careers and those who had families recognized they would make some sacrifice to their career. In this and other gender related experiences, these women did not waver from their passion and drive to be scientists.
This could be related to a strong sense of agency they each seemed to possess. Moreover, this sense of agency was fueled by the fact that being an only women in many cases was seen by them as a sign of distinction.

The impact of gender is often seen through the role men play in women’s access to science, especially in male dominated academic departments (CAWMSET, 2000; Lazarus, et.al., 2002; Monastersky, 2005; Rosser, 2000b; Rossiter, 1982; Steinpres, et.al., 1999). Also the notion that women are socialized in a certain way because they are women, would seem to limit their access to science (Brickhouse, 2001; Kleinman, 1988; Mason and Kahle, 1988). Neither of these seemed to be significant issues for these women. There were clearly issues relate to being in a male dominated department but these were barriers overcome and only one woman referred to a significant negative experience with a male mentor. Conversely, each woman identified significant male influences including men who supported them in their academic pursuits as mentors and advisors. Most notable were the number who saw their fathers as significant role models and sources of support and influence. Hackett and Byars (1996) found that African American women were more likely to aspire to male dominated careers than white women. They attributed this to exposure to more masculine experiences and less sex-typed gender role socialization in childhood. The way some of these women described the support of their fathers would be consistent with this possibility.

One significant impact of gender for women in science is the way in which they become marginalized in the profession (Eisenhart and Finkel, 1998). Eisenhart and Finkel (1998) say that the pervasive discourse on gender neutrality in science actually masks the gendered features of the workplace. They point to the experiences of women
in their study where attempts to create equal treatment at work actually mean women work under conditions of male expectations. Women take on males roles to become successful. This ends up marginalizing their experience in terms of what they have access to as well as they extent to which they can fully engage themselves as women scientists. One might question if the women in this study have masked the impact of gender in their own acceptance of male norms. At least one of the women referred to taking on male characteristics of a scientist. However, each present such a convincing picture of their own science identity the effect is that they do not perceive themselves or present themselves as working in the margins of their field.

The stories told here focus more on a sense of belonging and community than of marginality. Despite the minority status each woman has had throughout her career, there is a significant amount of focus on the experiences of the role of belonging to groups of like minded peers, research teams and the community of scientists. Perhaps this sense of community was a source of support in dealing with being a minority, but the point is that none of the women expressed feeling marginalized even though several had marginalizing experiences because of their gender.

The experiences of the women in this study cannot refute the fact that gender is significant in science, even though they may negate the role gender has had on their experience. What is most significant is that these women have not let gender related barriers keep them from the science profession. This may be due to the amount of support they had from families and mentors. This may be due to a strong sense of agency with which each approaches her career and goals, similar to the stories of other women scientists (Keller, 1983; Rosser, 2000; Rossiter, 1982; Schiebinger, 1989;
Shepherd, 1993). Clearly, Barbara McClintock (Keller, 1983) had that same sense of agency when she persisted in her career despite significant resistance from male colleagues because she was a woman. She also would not assign her gender as a source of difficulty or a barrier to her success.

Nel Noddings (1990) makes a distinction between what she calls first generation and second generation equity achievement. First generation equity achievement means women that women have gained the knowledge, credentials and positions that men have. Eisenhart and Finkel (1998) say that many women are at this level in practicing science because they do it in terms of the male paradigm. Second generation equity allows women to express their identity as women without sacrificing the knowledge, credentials or achievements they attained. Each of the seven women in this study have certainly achieved this first generation equity. But none of them would think that was good enough. It is likely that most would see themselves at the second generation, even though they would acknowledge that women are still treated differently in their profession than men. Eisenhart and Finkel (1998) would say that women are made more vulnerable if the act like women in science professions and hence this second generation equity is mostly non existent. This is certainly supported by some of the recent reports of women in the science academy (Wilson, 2004; WISELI, 2004). These seven women might agree with that for others though not necessarily for themselves.

**Constructing an Ideal Type?**

Each of the women in this study offer an example of what a successful female scientists looks like. Even though they are in different fields of science, have pursued very different avenues of research and have different family and educational backgrounds
they have many shared elements of experience. Despite their individual differences their stories have provided some common themes that allow one to describe an “ideal type” for accessing science as a woman. Like the women who have gone before them, they are exemplars of experience. In this way, one might conclude from their stories that science is accessible to women and whatever barriers exist can be overcome. While other may disagree with this generalization, it is still possible to offer these narratives of experience and this template of an ideal type as a form of instructing or mentoring aspiring scientists.

The six themes identified in this study help to describe this ideal type. Figure 2 shows these six themes and suggests they are each central to the development of a strong sense of science identity and agency. Each of these themes contributes to the construct of an ideal type. The data collected does not allow for a relative measure of how each theme supports this identity and agency. The personal experiences with science are very significant and these include practical and personal experiences as well as formal schooling. This woman has an interest in science at a young age and this is supported by a caring and nurturing family environment that values education and supports the child’s aspirations. This aspiring scientist has a passion for things of the mind, not only science areas but other subjects as well. She has a strong sense of curiosity and passion for discovery, modeling and problem solving. Her sense of self efficacy is characterized by a sense of herself as a strong student who values independence and hard work. This self efficacy is supported by a vision of herself as a scientist and a belief that she has special talents that support that vision. This is confirmed and supported by others in her family and educational circles. She is motivated by an ethic of care that drives her towards using her science to help others, solve problems, and make a difference in the world. She can
identify at least one significant role model and realizes the impact that person has had on her self efficacy in science. She does not consider herself marginalized and to the extent that she is a minority in her experiences she sees this as more of an opportunity than a barrier. For the most part any barriers she encounters she identifies as her own responsibility and finds ways to overcome them or makes adjustments in her goals to find success.

These individual stories and the ideal type construct can support initiatives in science education and the development of a feminist pedagogy in science. This pedagogy includes the importance of hands on and practical experience (Barton, 1997; Kahle and Meece, 1984; Roychoudhury, et. al., 1995), the support of role models and mentors (Evans, et. al., 1995; Milne, 1998; Smith and Erb, 1986; Tobias, 1994; Zacks, 1999), situated learning or the personal relevance of science (Barton, 1997; Brickhouse et.al., 2000; Brickhouse, 200; Martin and Brouwer, 1991; Meyer, 1998; Milne, 1998; Richmond et.al., 1998; Rosser, 1990; Roychoudhury, et. al., 1995) and the importance of care and moral development (Gilligan, 1982, Noddings, 2003).

Models of Gender and Science

Relating these seven stories to Kahle’s (1983) model of gender and science (Figure 1, Appendix A), one might conclude that the socio educational context of their experience led to positive outcomes in beliefs attitudes and behaviors. In this study that context included family support, childhood experiences, formal and informal educational experiences, and support from others. They saw themselves as good science students with the agency and efficacy to pursue science. This study cannot make any conclusions
about the involvement of teachers except to note that each woman related positive memories about influential teachers.

Rosser’s (2002a) seven stage model of curriculum and pedagogy would support the use of these stories as techniques to evaluate science and its social context. In particular, students could examine the influence of gender in the pursuit of science and also the various social and cultural influences that impacted identity and agency in science. As exemplars of experience these women could offer insights into the barriers one might face in pursuing science and the ways those barriers could be overcome.

As feminists and educators have suggested (Barton, 1997; Evans, et.al., 1995; Martin and Brower, 1991; Meyer, 1998; Richmond, et. al., 1998; Rosser, 2000; Smith and Erb, 1986; Zachs; 1999,) the stories of women scientists can be instructive narratives for students of science. The idea that these women might present an ideal type or at least characteristics of what it take to could be informative for anyone seeking to pursue science or perhaps for the caring teacher (Noddings, 2003) hoping to influence students in that direction. These women’s stories are instructive about the areas that influenced their pursuit of science, specifically a passion for science and intellectual curiosity, the support of family, the impact of role models and mentors; opportunities for practical and relevant science experience and a strong sense of agency fueled by their academic ability and belief in their potential to be scientists.

Assertions

Based on the analysis of these seven stories the following assertions are offered about the experiences of successful women scientists. Due to the nature of this study these are not meant to be generalizations, but rather ideas that might be developed for further
study. They might also be considered by aspiring scientists as points of reflection about their own experience.

1. A passion for science combined with a desire to help others creates a sense of agency that is significant to overcoming barriers to participation in science.

2. Gender is still an issue in pursuing science and with a strong sense of agency can be negotiated as a barrier outside of self.

3. For some women, the experience of being a minority as a woman in science can be more significant to promoting self-efficacy and agency than to being marginalized.

4. Role conflicts between personal and professional life create barriers that are not easily overcome.

5. While acknowledging that scientific practice is still dominated by men, women scientists are able to create their own image of scientists as women through the science experiences they choose and the support they receive from others.

6. Women can engage themselves in the scientific community in a way that negates or minimizes the sense of being marginalized.

7. The lived experience of women pursuing science acknowledges the social nature of science while this experience validates scientific practice.

8. The stories of contemporary scientists can be incorporated into feminist pedagogy as exemplars of experience about the way women negotiate gender-related barriers in the pursuit of science.


Clewell, B.C. and Campbell, P.B. (2002). Taking stock: where we’ve been, where we are, where we’re going. *Journal of Women and Monitories in Science and Engineering, 8*, 255-284.


Appendix A. (Figure 1). A model of the relationship between gender and science (Kahle, et.al., 1993)
Appendix B. Demographic Survey

Part A. Demographic Information (can be substituted with CV or resume)

Name ___________________________ Date of Birth ____________

Address ________________________________________________

Phone number ______________________ Email address ____________________________

Preferred method of contact (Please check one)
Phone _______ Email _________ Either _____________

Educational Background (starting with most recent)

<table>
<thead>
<tr>
<th>School</th>
<th>Dates of attendance</th>
<th>Degree(s)</th>
</tr>
</thead>
</table>

Professional Experience

<table>
<thead>
<tr>
<th>Position</th>
<th>Employer</th>
<th>Dates of employment</th>
<th>Description of duties</th>
</tr>
</thead>
</table>

Teaching experience (if not included above)

<table>
<thead>
<tr>
<th>School</th>
<th>Dates</th>
<th>Grade level</th>
<th>Subject(s)</th>
</tr>
</thead>
</table>

Research
Part B. Personal background and family history

Place of birth________________________________________

Father’s occupation:______________________________ Highest degree: ______

Mother’s occupation:______________________________ Highest degree: ______

Number of siblings:_______ Place in birth order:_______

List any family members by relationship (ie. father, aunt etc.) who were scientists;

List any individuals (by relationship) who had a significant impact on your decision to become a scientist;
Appendix C. Informed Consent

Informed Consent Form

Factors Influencing the Occupational Choices and Experiences of Women Scientists

Introductory Statement
Before agreeing to participate in this study it is important that the following explanation of the proposed procedures be read and understood. The description includes the purpose of the study, its procedures and any associated risks and/or benefits. It also describes the right to withdraw from the study at any time. It is important to understand that no guarantee or assurance can be made as to the results.

Purpose
I understand the purpose of this study is to capture, through oral histories, some of the major influences on women scientists. It will look more specifically at how my family, educational background, and experiences with science affected my occupational decisions and the nature of my work as scientist. I, __________________, give my permission to participate in the research where the researcher will interview me to determine how these influences affected my career as a scientist.

Procedures
I understand that the researcher will interview me to obtain an oral history of my work as a scientist and the factors that influenced that work. It is expected that these semi-structured interviews will be conducted in two sessions that are approximately 2 hours in length. The interviews will be tape-recorded. These recordings will be transcribed by the investigator and/or a professional transcriber. The notes will be coded to determine the significant factors of influence.

Financial Costs/remuneration
I understand that I will incur no financial costs and that I will not be paid or otherwise compensated to participate in this study.

Potential Risks and Benefits
I understand that this study is intended to benefit me and other potential scientists by gathering information about the influences that affected my experience and career as a scientist. Although there are no implicated risks associated with this research, I understand that discomfort may result from my being interviewed by the researcher and/or discussing my thoughts and feelings about my life. Should discomfort or other problem occur, I understand that I have the right to decide whether or not to remain in the study. I also understand that I may discuss my discomfort or problems with the researcher (Laura Koehl, 859-441-0815), the researcher’s advisor (Dr. Annette Hemmings, 513-556-3617) or Dr. Margaret Miller, Chair of the Institutional Review Board – Social and Behavioral Sciences at 513-558-5784.

Rights of Participants
I understand that participation in this study is strictly voluntary. I may refuse to participate without penalty. If I do choose to participate, I may withdraw from the study without penalty at any time with a verbal or written request for termination. I also understand that I have the right to contact the researcher or the researcher’s advisor should any questions or concerns arise.

Confidentiality and Disposition of Data
Information gathered during the interviews is considered data for this study. I understand that to ensure confidentiality my name will be changed or removed from all written data including field notes and interview transcripts and that no real names will be used in the written and oral reports of the study results. I also understand that no one except the researcher and transcriber will have access to audio tapes, and that all data will be stored in a locked file cabinet and destroyed after the study is completed.

Consent Statement
I, the undersigned, understand the above explanation and give my consent to voluntarily participate in this study which investigates the factors influencing career choices and experiences of women scientists.

Signature of Participant_____________________________ Date _______________

Signature of Investigator_____________________________ Date _______________
Appendix D. Interview Guide Round 1

Global questions

1. Please give me an overview of your personal history focusing on your family background and educational experiences.

2. As you look at your life overall, please describe how you decided to become a scientist and any experiences that influenced you along the way.

3. Discuss the social and cultural variables that you think were significant through your personal and professional development.

Family Background

1. In what ways did your family support your decision to become a scientist? In what ways did they support your ongoing work in science and scientific pursuits?

2. Were there any other people in your nuclear or extended family that had an influence on your professional choices? Please describe those individuals and their influence.

Educational Background

1. What are some descriptions of your school experience? What kind of student were you? How did you feel about school? Are there any particular memories of school that define your experience and decision to become a scientist?

2. Were there specific people or educational experiences throughout your science education that had a significant impact on your decision to pursue science? Can you describe those individuals and experiences and their influence?

3. What experiences did you have outside formal education that affected your learning and interest in science?

Experiences With Science

1. Describe your area of research and how you chose it.

2. How have your experiences with science influenced your ongoing pursuit of this profession?
3. Please describe events in your life as a practicing scientist that you think would be informative to potential students of science.

Closing Questions

1. Are there any areas or questions that I have not asked that you think are relevant to our discussion?

2. Overall, can you name the three most significant experiences that affected your choices to join the science profession and your subsequent work as a scientist?

3. If you could go back and change anything about your decision to become a scientist and the way in which you practice your occupation, what might it be?
Appendix E. Interview Guide Round 2

1. Can you identify some “defining moments” for you in your scientific career and describe how they affected you ongoing pursuit of science? Can you remember when you knew you wanted to be a scientist and anything about that time?

2. What, if any, barriers do you think you had to overcome to be a scientist? How did you handle those?

3. Describe any specific experiences that kept you going in your pursuit of science.

4. In what ways did your gender affect your pursuit of a science career? Can you give any specific examples when gender was either a positive or negative factor?

5. In your experience, have you seen any differences in the way women pursue science versus the way men do?

6. Can you recall your perceptions of who could be a scientist and did you have to redefine that perception in any way as you pursued a scientific career?

7. What qualities do think a person should possess to be a successful scientist?

8. How has your work as a scientist defined or redefined what it means to practice science?

9. What personal qualities do you think you have brought to the pursuit of science?

10. What stereotypes of science do you think your own experience has challenged/dismissed?

11. Did your role as a scientist ever conflict with other roles you played and can you describe those experiences/events?

12. What advice would you give a young woman wishing to pursue science?
Appendix F. Reflexivity of the Researcher

I feel I was able to establish rapport with the women who participated in the interviews. We spoke by e-mail and phone several times before we met. I think they assisted me in obtaining rich and informative data and I sensed that each woman found the process to be engaging and positive. Each woman seemed comfortable sharing her stories and did not ever ask me to delete any information or shy away from sharing personal aspects of her life. I think the women found it rewarding to share their stories.

I considered the women to be very honest and insightful in their remarks. I felt they trusted me with their information and were able to share any questions or concerns they had with the study as it progressed. I feel they trusted me to keep these stories confidential. The process of asking questions through the two interviews and the dialogue that ensued helped me to establish a relationship with each participant.

The participants were aware that I was a graduate student, working for the university on an NSF fellowship and that I had some of my own experience with science. I believe I conveyed a genuine interest in the pursuit of science for women and that they were willing to participate in the project in part because of they way it might support any efforts in that area. They each seemed willing to share their stories with young women considering science although for my part that would only be through the use of pseudonyms.
**Appendix G. Coding Themes**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Experiences With Science</td>
<td>early interest in science, math</td>
</tr>
<tr>
<td></td>
<td>female vs male approach</td>
</tr>
<tr>
<td></td>
<td>gender is an issue</td>
</tr>
<tr>
<td></td>
<td>gender not an issue</td>
</tr>
<tr>
<td></td>
<td>hands on experience</td>
</tr>
<tr>
<td></td>
<td>impact of childhood environment</td>
</tr>
<tr>
<td></td>
<td>early experience/interest in science</td>
</tr>
<tr>
<td></td>
<td>importance of practical experience</td>
</tr>
<tr>
<td></td>
<td>professional experience</td>
</tr>
<tr>
<td></td>
<td>role conflicts, work and personal</td>
</tr>
<tr>
<td></td>
<td>sees equal access for women</td>
</tr>
<tr>
<td></td>
<td>sees unequal access for women</td>
</tr>
<tr>
<td></td>
<td>social nature of science</td>
</tr>
<tr>
<td></td>
<td>structure in science unappealing</td>
</tr>
<tr>
<td></td>
<td>women - lower expectations</td>
</tr>
<tr>
<td></td>
<td>women have to work harder, more self</td>
</tr>
<tr>
<td></td>
<td>women sacrifice personal/professional goals</td>
</tr>
<tr>
<td>Support of Others</td>
<td>father as role model</td>
</tr>
<tr>
<td></td>
<td>father's role in supporting</td>
</tr>
<tr>
<td></td>
<td>female influence negative</td>
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<tr>
<td></td>
<td>female influence positive</td>
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<tr>
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<td>female mentor, role model</td>
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<tr>
<td></td>
<td>male influence negative</td>
</tr>
<tr>
<td></td>
<td>male influence, support</td>
</tr>
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<td>male mentor influence negative</td>
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<td>male mentor influence positive</td>
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<tr>
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<td>mentors, role models</td>
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<tr>
<td></td>
<td>mother as role model</td>
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<td></td>
<td>mother's role in supporting</td>
</tr>
<tr>
<td></td>
<td>teacher influence - positive</td>
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<tr>
<td>Passions of the Mind</td>
<td>valuing discovery and curiosity</td>
</tr>
<tr>
<td></td>
<td>love of academics, intellect</td>
</tr>
<tr>
<td></td>
<td>love, enthusiasm for field</td>
</tr>
<tr>
<td></td>
<td>integration of subjects</td>
</tr>
<tr>
<td></td>
<td>interest in arts, music, writing</td>
</tr>
<tr>
<td></td>
<td>interest in research and investigation</td>
</tr>
<tr>
<td></td>
<td>scientific desire</td>
</tr>
</tbody>
</table>
solving problems, creating models
varied academic interests

Ethic of Care

filling a need,
interest in helping others
contributing through teaching
applying skills; knowledge
making science relevant, accessible
mentoring others
work in cutting edge

Self Efficacy and Agency

affirms science ability and interest
academic ability challenged
academic, science ability reinforced
contrary to family experience/expectations
defining a scientist
drive, initiative
education as a way out
family support, expectations
family values education/science
girls can do science
independent, survivor
making significant decision
overcoming hardship, barriers, criticism
persistence, going for better best
realizing interests, science identity
requires extra time/hard work/commitment
seeking independence, self sufficiency
sees self as strong student
sees unequal access for women in US
sense of competition w others
sense of self
value of recognition
well rounded experiences

Marginality vs. Belonging

access for women changing
community, team, collaboration
connecting w scientific community
finding others w similar interests
gender issues separated from self
minority experience as a woman
mostly male colleagues/fellow students
peer support
standing out in the crowd
support from others
overcoming hardship, barriers, criticism
taking on male role
women - lower expectations
women have to work harder, more self
women sacrifice personal/professional goals