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AN ANALYSIS OF WOMEN'S WAYS OF KNOWING
IN A 10TH GRADE INTEGRATED SCIENCE CLASSROOM

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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****

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1997

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ABSTRACT

All students can learn science, but how they learn science may differ. This study is about learning science and its relationship to gender. Women need to develop and establish connections with the objects that they are learning and be able to establish a voice in a science classroom. Unfortunately, traditional science classrooms still view science as a male domain and tend to discourage women from pursuing higher levels of science or science related careers. The ways that women learn science are a very complex set of interactions. In order to describe these interactions, this study explored how women's ways of knowing are represented in a high school science classroom.

Nine women from an enriched integrated biology and earth science class contributed to this study. The women contributed to this study by participating in individual and group interviews, questionnaires, journals, observations and participant review of the interviews. The ways that these women learn science were described in terms of Belenky, Clinchy, Goldberger, and Tarule's *Women's Ways of Knowing: The Development of Self, Voice, and Mind* (1997).
The women's ways of learning in this classroom tended to be situational with the women fitting different categories of knowing depending on the situation. Most of the women demonstrated periods of time where they wanted to be heard or tried to establish a voice in the classroom.

The study helps to provide a theory for how women make choices in their learning of science and the struggle to be successful in a male dominated discipline. The women participating in this study gained an awareness of how they learn science and how that can be used to make them even more successful in the classroom. The awareness of how women learn science will also be of great benefit to other teachers and educators as the work for science reform continues to make science a 'science for all'.
Dedicated to Mary and Austin Pottmeyer,
for their love and support
ACKNOWLEDGMENTS

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CHAPTER 1
INTRODUCTION, BACKGROUND, AND RATIONALE

There had been several reports indicating the differences in the educational experiences between men and women in the areas of science and mathematics (Shroyer, Borchers, Smith, and Wright, 1994; Pollina 1995; Erchick, 1996). Young women might not necessarily have different cognitive abilities, but might have different ways of learning that were rooted in their roles in society (Roychoudhury, Tippins, and Nichols, 1995). Women had not developed the necessary skills required in science and technology fields (Pollina, 1995). The lack of skill in science had led to women having lower levels of self-confidence and perceptions that science was a male domain (Weinburgh, 1995).

Teachers Role

Many teachers and guidance counselors perceived science as a male domain (Kohler, 1990). This sent a negative message to women about being successful in science or to dominate in this field. Women needed to feel connectedness
with their learning and knowledge (Belenky, Clinchy, Goldberger, and Tarule, 1986, 1997; Gilligan 1982; and Keller, 1985) and many times this conflicted with the "power over" message that science was seen to portray. Men and women had different ways of looking at life, but at the same time, science had been developed from the perspective of men (Harding, 1991). Women's ways of thinking did not always parallel the ways of science and therefore the current ways of learning science might discourage them from pursuing science.

Less Opportunity?

Women have had less opportunity with science and technology in and out of the classroom and had lower interest and achievement levels than men (Shroyer et al. 1994). As a result of these experiences, women were underrepresented at the higher levels of science (Pollina, 1995).

Today, there seemed to be an effort to rethink science by understanding how women think and process information, but it was a very complex issue involving many variables. The issue involved the individual woman, family situation, school environment, and societal factors (Shroyer et al. 1994).
My starting point of interest had come from observing young women in science classes for the past eleven years in a high school setting and from reading about women learning science in the research literature. I had learned and observed over these eleven years the voices of these young women who could and had succeeded in science as well as those young women who had been less successful in science. I could also relate to the struggles that many young women went through in learning science based upon my own past experiences associated with science.

In the study, I looked at young women in science and I realized that in some ways, their lives and experiences were different from women scientists. However, in other ways, such as their struggle to be successful in a male dominated discipline and to learn science, were essentially the same. In the writing of the research, the young women of the study would be referred to as ‘women’.

The Problem

Women and Careers

All students could learn science, but how they learned science might differ. Students varied according to race, gender, home culture, and past academic success to name a few. The study was about learning science and its
relationship to gender. Research had indicated that there were not enough women in science related careers (Kahle & Danzl-Tauer, 1991; Sonnert & Holton, 1996). For the women who were successful in science, they had developed a comfort level that allowed them to learn science successfully. However, some women had not developed this comfort level in learning science and had therefore not been as successful. The ways that women learn science in a classroom and the ways in which science was traditionally taught might lead to some of the conflicts that women experienced in science.

Studying a science classroom could help to explain why some women were successful and others were not. The way women gathered or processed information might be a determinant of the success that they might experience in the classroom. Past educational experiences might not have prepared them for being successful in science.

In a typical science classroom, women would go through different processes to gather information. Once the information had been gathered or given, women used different ways of knowing to decide what information to use and how to use the information. The women relied on many internal as well as external factors in determining whether something was fact or fiction. These thought processes were used by women in going through a science lab or activity as well as
a classroom lecture. The information gathered in the case study would benefit teachers and women in the area of science education.

Purpose

The purpose of the study was to look in depth at how high school women learned science, how they processed information, how they decided what information to use, and how this related to success in science. I would examine the processes that women went through in problem solving and analyzing information. The study would also observe the use of technology by the women in their science courses and how it corresponded with women’s ways of knowing science.

The way in which women learn science was a very complex issue and could not easily place all women into one category. There were many interactions and complexities that took place in a high school science classroom that contributed to success or lack of success. The ways that women learned science were directly related to their environment, past experiences, teachers and classmates. The women in the study might or might not be aware of how they learn science, and if not, this study might have a positive effect on their learning process. The elements that the women encountered in a science classroom when they attempted to learn science would also be examined.
Instead of trying to teach women new ways of learning science, we should instead look at how women learn science (Pollina, 1995). All students could learn science, the question was, "How did they learn science?". The women in the study could provide valuable evidence of how they learned science in the way that they did. Evidence had shown us that women could provide a real insight to learning and open new windows to understanding women’s success in science. For example, Barbara McClintock opened a new window into the field of genetics (Keller, 1983). McClintock’s “feeling for the organism” allowed her to gather information about genetics that her male counterparts could not. She found that by listening to the organism, she could gain new insights into her work. By listening to the organism, McClintock listened to her inner voice and was able to connect with the object that she was working with. A woman’s way of looking at science involves feelings and relationships to make connections within the discipline that will make the information gathering and processing skills unique.

Women’s Ways of Knowing

The framework for this study was based on Belenky et al.’s Women’s Ways of Knowing (1986, 1997). In this framework, themes and patterns were developed which more
adequately described women’s intellectual development. This framework was based on ten years of research involving 135 women of diverse backgrounds. The patterns and themes that emerged from their study were organized into five categories of knowing: silence, received knowing, subjective knowing, procedural knowing (separated and connected), and constructed knowing.

For a silent knower, the voice of authority and power lied with the authorities. In the case of this study, the authority was found in the teacher that was present in the classroom. The silent knower did not hear or believe that she could hear what the teacher was saying. She had very little confidence in herself or her ability to think and process information. The barrier for the silent knower was her self-image.

The received knower had similar ways of knowing to those of the silent knower. The received knower still believed that the authority or the teacher held all of the knowledge and would dispense it to her. The difference lied in that she did not experience the lack of hearing of the silent knower. Instead, the received knower believed that there was only one right way to do something or one right answer to a question or problem, usually determined by the
teacher. As with the silent knower, the barrier was usually a poor self-image or her ability to learn science.

A subjective knower personalized her knowledge. This type of knower began to realize that the authority figure or teacher did not hold all of the information or knowledge. She began to rely on her inner voice and began to move to become her own authority. She did this by gaining confidence in herself and making connections with the knowledge that she was learning. Each time that she was successful with an answer, she began to realize that she held a part of the knowledge, as well as the teacher.

In order for a woman to be completely procedural, she needed to demonstrate both a separated and a connected way of knowing. The separated procedural knower maintained a separation between the knower and the object. She forced herself to learn what the authority or teacher wanted her to learn and to think.

The connected procedural knower focused on becoming personal with the object and the knowledge. She looked for common experiences and tried to make connections with her classmates. The connected procedural knower needed hands-on experience to examine and evaluate evidence in order to make conclusions.
The constructed knower integrated her feelings and thoughts to develop her total sense of being. She developed her own voice of understanding as well as her own authorities. The constructed knower was very interested in understanding why people thought or believed in the way that they did.

The framework that Belenky et al. used was different than what was found in traditional science classrooms. Most traditional science classrooms did not provide environments that encouraged women to develop or move into other ways of knowing. These classrooms encouraged the silent or received knowers. In order for women to process and internalize the information in a science classroom, they needed to be able to connect with the information that was presented to them.

**Strategies**

The best way to learn lessons from women in science was to observe, interview, and record them actually doing science (Pollina, 1995). Women did not necessarily think in right/wrong categories, and information seeking would reflect this. Women needed to be able to synthesize information and make connections in gathering and processing information. I was well aware of the fact that men also needed to make these connections, but for the purpose of the study, only the women had been studied.
Women were also avid note-takers and would get so absorbed in taking notes and copying everything down, that they sometimes missed out on participating in discussions (Pollina, 1995). According to Ellsworth (1994) dialogue and discussion was offered as a pedagogical strategy for constructing learning conditions and consisted of certain ground rules for classroom interaction. These rules included the assumption that all members had equal opportunity to speak and all members had a right to speak and feel safe in a classroom. However, this was not always the case for all women in a high school science classroom. The lack of dialogue or discussion could actually hinder a woman’s way of learning science in a high school classroom. In seeking information, women would need to process what information was important and understand how it could be useful to them.

What Is Science?

Perceptions among high school women concerning what science was and how they were supposed to learn also provided barriers to women knowing science. Science could be defined as “a way of knowing that is characterized by empirical criteria, logical argument and skeptical review” (National Science Standards, 1996, p. 21). Students developed an understanding of “what science is, what science
is not, what science can and cannot do, and how science contributes to culture.” (National Science Standards, 1996, p. 21). The National Science Standards (1996) stated that understanding science required a student to integrate a complex structure of many types of knowledge, “including the ideas of science, relationships between ideas, reasons for these relationships, ways to use the ideas to explain and predict other natural phenomena, and ways to apply them to many events” (p. 23).

Learning science was something that students did, and not something that was done to them (National Science Standards, 1996, p. 20). The standards also stated that “in learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others” (National Science Standards, 1996, p. 20).

Whatever science was to these women, and how women felt about science and their learning was directly connected to what women perceived science to be. Many women could not make connections between science and the real world and therefore tended to view science as not being useful in their lives (Roychoudhury et al. 1995).
Science as a Male Domain

Teachers who viewed science as a male domain actually contributed to women’s lack of confidence in a classroom. Science, for the most part was based on logic, and the fact that science was dominated by men made many women feel alienated when it came to learning science (Roychoudhury et al. 1995). The literature had shown that the prime reason for women’s avoidance of science was based on the masculinity of science (Kelly, 1985 and Rosser, 1989). Women were socialized from an early age to value different activities and goals than men putting them at a disadvantage when it came to learning science.

Unfortunately, the women in a science classroom might go about learning more by rote, than by making the necessary connections that would help them to make practical connections to the real world (Ridley & Novak, 1983). This occurred because many women had been taught or “socialized” to do as they were told and not to think on their own (Olsen & Maple, 1995). However, this thinking on their own was a very big part of science inquiry. Some women might struggle in deciding what information was important if there was little direction from the teacher. Women were often unaware of their own learning approaches and needed to think about their own thinking (Novak & Gowin, 1984).
Women Can Learn Science

Despite all of these factors, many women were choosing to take more science courses and to continue to learn science (Shroyer et al., 1994). The women in the study had achieved academically in the area of science and were recognized as unique among high school women because of their success. Women were very capable of doing and learning science and the studies with these women would help other women in understanding how to be more successful. Many women today had come to believe in themselves and their abilities to do science.

Reform Movement

The National Science Standards (1996) were based on the concept of science for all. This included a science curriculum that would encourage more women in the field of science as well as make connections with their daily lives. Teaching methods and learning styles needed to be altered to make science truly a 'science for all'.

This was not a study of women in general, but of particular high school women in particular situations during a period of their tenth grade year. The women participating in this study were all in an enriched science classroom and were selected for the study because they had been very successful in learning science. Most of these women had
tried to find ways to connect with science and to strengthen their learning in order to be successful.

Research Questions

Women science students would be able to provide the answers to the following research questions:

• What ways of knowing science have the women in this class developed in the past?

• What ways of knowing do the women in the class continue to develop in order to learn science?

• How do the women of this study maintain or move away from a particular way of knowing?

• How do the various ways of knowing relate to the womens' feeling of confidence in a science classroom?

• How do women learn science?

• Through the use of several integrated science lessons, how do women science students solve problems in learning and knowing science?

The women in this science classroom were the subjects of the study. The subsequent narratives provided an in-depth look at these womens' information seeking processes.
CHAPTER 2
REVIEW OF RELATED LITERATURE

History

Historically, women had always had to fight to establish position or recognition in the field of science. During the nineteenth century, many women were excluded from scientific educations, postdoctoral laboratory appointments and access to scientific publications (Harding, 1989). For centuries, women were barred from academies and universities for no other reason than their sex (Schiebinger, 1989). Between 1978 and 1980, the employment of women in science and engineering increased over five times faster than the employment of men. Despite this growth, women represented only about 13% of all employed scientists and engineers in 1989. (Gornick, 1990)

Accomplishments of Women Scientists

Rossiter (1982) had catalogued many of the accomplishments of women scientists that had been left out of the traditional history of science. These included, but were not limited to: the work of Madame Curie, Barbara McClintock and Rosalind Franklin. In Rosalind Franklin’s
case, her work on the structure of DNA was stolen by her colleagues. Gornick (1990) believed that if Rosalind Franklin had had someone with whom to talk or share information of her notes, she would have realized what she had. The DNA information was all there in her notes and photographs, but working in isolation, she was unable to share what she had discovered. Many other women found themselves in the same situation as these women scientists.

Marie Curie was the first person to win two Nobel prizes but she was denied membership into the prestigious Academies of Science in 1911 because she was a woman (Schiebinger, 1989). A woman was not elected to full membership in the academy until 1979, three hundred years after it first opened its doors.

Traditional Science

Harding (1989) made a statement that fit very well with how science was traditionally taught: "The way the work force of science is organized leads one to wonder not why there are so few women who have entered and remained in science, but, instead, how there can be any women in science at all". The work force in science was heavily dominated by men and usually the women were mere assistants to these men. Young women did not see careers in the sciences as something
that they could be successful in. Women's ways of knowing science shed new light into the way science should be "science for all".

Science Anxiety

In general, most women suffered from science anxiety and obtained low achievement in science classrooms. Some women had a fear of success in science because it was traditionally thought to be a male field (Erchick, 1996). Men dominated professorships at the post secondary level and therefore there were fewer women available as mentors for women students (Roychoudhury et al. 1995).

Teacher influence on women in science was connected to more than attitudes and perceptions of science. The influence was also connected to teacher classroom behaviors. Teachers generally had fewer interactions with females than with males (Barba & Cardinale, 1991). The teachers also had differently styled interactions with men than women as well as different expectations for specific behaviors. The teachers tended to let the males be more vocal and get away with more disruptive behaviors than the females.

Weinburgh (1995), found that over the past 21 years, boys had consistently shown a more positive attitude toward science than women. She even recommended further research in looking at the classroom strategies that were being used in the science classrooms to help improve women's attitudes
toward science. Belenky et al. (1986, 1997) believed that looking at how women learn, in terms of making connections, could produce a more positive attitude and outlook on life for these young women in science.

A study by Barr and Birke (1994) interviewed women and their perceptions of, and experiences with, science. The results of their study showed that women saw scientists as both quite unlike ordinary people and endlessly engaged in solitary work. Neither of the lifestyles that scientists portrayed were very appealing to women. The women saw themselves as passive consumers of scientific knowledge in the classroom. They not only felt excluded from science, but resisted science in the form it was presented to them.

**Current Statistics**

Today, research had shown that women elected to take fewer advanced science courses than men and were underrepresented in the science work force (Shroyer et al. 1994). Even high school women who were highly competitive in science tended to be less likely to major in science and more likely to drop out if they did select this area (Campbell, 1992). Baker (1995) indicated that schools were failing to provide environments that were conducive to women's learning.
Successful Science

Making Connections

Gilligan (1982) had found that most women that were successful described themselves in terms of relationships and connections that they had made. Shepard (1993) found that women learn science by making connections and establishing relationships to the objects of study. The feeling of connectedness had led to breakthroughs in the fields of primatology and genetics, but the women scientists reported conflict with their male colleagues (Shepard, 1993).

A comparison of educational treatment between men and women also revealed gender differences in the area of science. The study concluded that women and men received differential treatment in the science classroom (Barba & Cardinale, 1991). Regardless of age, observation length or grade level, educational differences did exist on a consistent basis. The differences favored the male students because they were more likely to have more interactions with the teacher and were more likely to ask for help. The males were also noted to have more informal contact with teachers, making the teachers more approachable (Koehler, 1990).

Making Meaningful Learning

Ridley and Novak (1983) suggested that meaningful learning actually occurred less often for women than for
men. When women were continually exposed to learning where they could not make connections, they eventually lost interest in the subject area. Making connections in learning was very important for women (Belenky et al. 1986).

Fennema and Peterson (1985) believed that women did not develop the type of autonomous learning styles needed to solve complex problems. This was due to a difference in educational experiences that men and women came in contact with. Women had a tendency to avoid problem-solving situations and would take fewer risks than men. Women were also less vocal in the classroom and would tend to view men as the authority figure (Gilligan, 1982 & Tannen, 1990).

**View of Authority**

There were several ways of knowing that varied according to the women’s relation to authority. A study by Brown in 1989 with 10th grade women and their views on authority revealed that 29% accepted authority as the source of truth. Moving into adolescence, women articulate increasing self-doubt that was evidenced by the persistent echo of “I don’t know” in their speech. The adolescent female no longer knew themselves or what they once knew.

Traditional science classes did not start with what the woman already knew. Unfortunately, knowledge began with teacher knowledge (Belenky et al. 1986, 1997). In separate knowing, one took an adversarial stance toward new ideas and
the typical mode of discourse was argument. A separate knower needed to know that their views could survive the scrutiny of an outsider’s critical eye. In most science classrooms, science was taught from a separated knowing style which most women felt uncomfortable with (Maher and Tetreault, 1996).

**Subjective Discussions**

Women in science classes were more comfortable learning science if they could make connections with the objects they were studying. Classrooms should encourage subjective discussion that would encourage students to air their opinions or relate their experiences in an atmosphere of nonjudgmentalism (Stanton, 1996). A connected discussion would go beyond that, pointing out where opinions were different, helping participants to discover the source of, and reasons for, the differences. The discussion also explored the implications of each position, and asked the class to reconcile different opinions.

**Effective Teachers**

**Giving Women a Voice**

An effective teacher would welcome students experiences into the classroom (Stanton, 1996). This gave the women in the class a voice that was related to the students’ capacity to formulate and air their thoughts. The women would believe that they had something worthwhile to say and would
feel that they were being heard. This in turn would encourage more women to actively participate in discussions and dialogue.

Too many times in a traditional classroom, the women were silent in terms of discussion. Blyth Clinchy (1989) reported that in interviews she conducted with Claire Zimmerman, men spoke of arguments as intellectually stimulating and useful to all participants. The men believed that it was a way of clarifying one's own thinking and of helping others to think more clearly. However, women saw arguments as a "zero sum game" where only one side could win. When the women spoke of arguments, they spoke of them as being crippling and recalled occasions when they were reduced to silence and tears.

Theoretical Framework

Many proponents of reform agreed that science learning should be grounded in learners lived experiences and proposed constructivism as the appropriate referent for teaching (Baybee, 1993; Project 2061, 1990). Constructivism placed the learner at the heart of teaching and the learning enterprise. Knowledge was constructed by cognizing through the women's experiences and reflections on their experiences. The women felt a need to make sense of one's experiences and constituted the core of learning (Roychoudhury et al. 1995).
Observations and data could be essential tools for the discussion, debate and dialogue that ensued in group learning situations. The interactions with peers would enhance learning.

For women, the importance of seeing connections, feeling connected with what they were doing, and working collaboratively was considered to be a valuable facilitator of learning (Roychoudhury et al. 1995). Working in cooperative groups to pursue their interest might be a supportive environment for women. Such an interactive and cooperative environment while facilitating the participation of females might also disrupt the balance of power in the classroom where the teacher was defined as the expert and privileged to dominate the discussions.

**Cognitive Styles**

Women make these connections and learn science through different means. Ausubel (1968) defined cognitive styles as individual differences in cognitive organization and various self-consistent personal tendencies that were not reflective of human cognitive functioning in general. Ausubel also used this definition to help differentiate between meaningful learning and rote learning. Constructivism would produce more meaningful learning for the women in a science classroom.
Constructivism was a way of building up about self, school, everyday experience, and society through reflection and meaning making (Shor, 1992). Constructivism provided a meaningful learning experience for all students and could help women in a science classroom by making the necessary connections to the real world. Kutz and Roskelly (1991) stated that constructivism added connections to the outside world, helped to problematize situations and concepts, redefined school literacy, used student inquiry to help determine the curriculum and made revisions by reseeing the old. Mahoney (1996) stated that in constructivism the students became active participants in the structural processes that characterized knowing. At the core of constructivism were five independent themes: activity, order, social-symbolic processes, identity and development. The overall theme of constructivism was that the emphasis was on the importance of human relationships and their roles in both personal and collective experiences.

Constructivism was not necessarily a curriculum, but more of a way of thinking about how students learn. In this study, constructivism looked at what the women knew coming into the classroom and used that to make connections and went further in their learning. Constructivism had encouraged educators to realize that not all students learn
by the same methods and if students could build on past knowledge, more internalization of knowledge would take place.

John Dewey's Creed

Constructivists, as defined by John Dewey's pedagogic creed (1963), believed that education was a result of "the empowerment of the learner in a social situation" (Dewey, 1938). The learner was continually becoming a member of a community and this allowed her to see herself in the eyes of the community. Dewey was a firm believer that the schools were very valuable in helping learners construct knowledge socially.

Constructivism was critical to the woman learner because it strived to look at inquiry as an approach to knowing, rather than the unquestioned acceptance of prevailing knowledge. This concept fit very nicely with the constructed knower defined by Belenky et al. (1986, 1997).

Vygotsky and Piaget

The grandfathers of developmental psychology, Jean Piaget and Lev Vygotsky, posit language as central and indispensable in human development (Tarule, 1996). However, they differed significantly in their analysis of the development of language and its relation to learning.
**Vygotsky's Theory**

Vygotsky's theory was based on speech development in a social interaction (Tarule, 1996). First the child acquired language by internalizing the external voice of caregivers and later as inner language and voice of one's own will. He emphasized the role of interaction with others as central to human growth.

**Piaget's Theory**

Piaget established a theory that was very important in science education. Piaget believed that knowledge was not passively received either through the senses or by way of communication. Knowledge was actively built up by the cognizing subject (von Glasersfeld, 1990). A person felt no need to learn certain topics or concepts if they were not perceived to meet some personal goal. Women were more interested in science if they understood how the information they were gathering fit with what was happening in the real world (Baker, 1995).

Piaget’s theory was based on the concept that understanding was built as the individual undertook action on objects and reflected on the results of these actions (Tarule, 1996). Piaget believed that understanding preceded language, which was therefore developed after the fact to describe and report on the newly apprehended word. Relationships and social interaction were never critical to
Piaget's theory. Cognitive development was an individual process that might be influenced by social interaction.

In contrast, Vygotsky viewed cognitive development as a "socio-cultural" process that was conducted in participation and communication with others (Rogoff, 1993). This view was very similar to the separate and connected ways of knowing presented by Belenky et al. (1986, 1997). Piaget's theory was more like the separate knowing stage by Belenky et al. (1986, 1997) by placing an emphasis on how knowing developed through interaction with the objective world.

Vygotsky's theory, as in a connected knower, was based on how thinking and knowledge were mediated through an interaction with others. Vygotsky did not see thought and language as the same. The meaning was always changing because the relationship between word and thought was constantly changing (Tarule, 1996).

Vygotsky (1986) believed that learners were moved forward through cognitive stages through socially mediated situations. He also believed that "culture is the product of social life and human social activity" (Vygotsky, 1986). Vygotsky (1978) viewed learning as a social process that emphasized dialogue and the varied roles that language played in instructions and in mediated cognitive growth.
The mere exposure of students to new materials through oral lectures neither allowed for adult guidance nor for collaboration with peers.

In many science classrooms, women were not a part of these socially mediated situations and tended to feel disconnected. Low levels of confidence and self-esteem could result. Constructivism was a way to break the mold of traditional learning methods and provided women an opportunity to be an active participant in their learning.

**Dialogue and Discussion**

**Collaborative Learning**

The concept of dialogue was very important with making learning practical and real to women. Dialogue helped to develop meaning and enhanced knowledge to all participants. Collaborative learning was a very valuable tool to encourage dialogue (Tarule, 1996). Collaborative learning assumed that knowledge was a consensus among the members of a community of knowledgeable peers. The knowledge was something that people constructed by talking together and reaching agreements. Collaborative learning gave the students a voice in their learning. Research had shown that groups that were led by a guide were different from groups that were led by an authority (Tarule, 1996). In this case, the authoritative voice was no longer held by only one person; it was lodged in the discourse. The way that a
classroom was structured and the role that the authority took, shaped not only the discourse, but the meaning the student made: it was or was not learning.

How did one go about learning something new? Most research showed that students did not invoke the voice of an expert (Tarule, 1996). The research showed that the students would usually ask someone or talk to a friend. The actual learning took place in the conversation.

In a traditional lecture, the only ideas that were being exchanged were the teachers. It was just a one way exchange of ideas. In a collaborative classroom, learning was a two way exchange between the student and the teacher, as well as student to student. Authority was not abandoned in this type of classroom, but silenced to allow for absorbing the authority of another or while constructing a new group authority.

Constructivism opened up a whole new field for education because it broke through the traditional barriers of where knowledge came from. Constructivists would challenge this traditional philosophy that there was a fixed body of knowledge to be learned. In most cases, this was the knowledge transmitted from the teacher to the student.

Women’s Ways of Knowing

Keeping this constructivist approach in mind, the model presented by Belenky, Clinchy, Goldberger & Tarule (1986,
would be used to examine how women processed information in science. This model presented ways to look at the patterns that best described a women’s intellectual development.

The *Women’s Ways of Knowing* model was based on ten years of research with 135 women of diverse backgrounds with respect to education, culture, race, age, and class. The model was developed as an alternative to William Perry’s model from the 1970s involving all male subjects. *Women’s Ways of Knowing* was designed to describe women’s intellectual development and patterns that Perry’s model left out. Experiences Belenky, Clinchy, Goldberger, and Tarule considered as educational were not limited to formal schooling. The authors explored learning experiences in schools, in public assistance programs, in family structures and in social communities. All learning and all voices were valued (Erchick, 1996).

Instead of imposing theories about cognition, in *Women’s Ways of Knowing* the authors began with their women respondents, listening carefully to how they defined powerful learning experiences and went about gathering knowledge and making meaning.

The ideas from the model developed five categories of knowing. They were as follows:
The Silent Knower

Silence: The silent woman felt as if she could not really hear the voice of authorities or believed that she could understand any explanations from authorities. The power lied with the authorities and she was taught not to question authority. This type of knower got knowledge through concrete experiences, not words. She saw herself with little ability to think on her own (Stanton, 1996). Belenky et al. (1986, 1997) found very few women fitting this category in their study. In the classroom situation, this woman would ask for no explanation if she thought that the teacher’s answer was wrong. However, many women at this stage did not even have enough confidence to believe an answer was right or wrong. In her opinion, the teacher knew everything and was never wrong. This student might even respond this way to a “superior” student in the class. Low self-esteem and confidence forced this student to feel that everyone else had a better answer or better way of gathering information.

Since the original study of Women’s Ways of Knowing in 1986, much had been written about their results. Stanton (1996) believed that the silent knower or quiet knower was not necessarily a passive knower, but might be working hard to receive knowledge. Ruddick (1996) also believed that the
silent knower in the original study was understood to be totally negative and at the bottom of the knowing continuum.

Schweickart (1996) stated that the silence of the listener did not mean that she was doing nothing and producing nothing. She was actively engaged in producing the meaning of the other’s utterances. Silence in the classroom or while working on a problem was not the sign of passivity, but of the most intense “intellectual engagement, intellectual autonomy and independent effort to understand” (Schweickart, 1996).

Goldberger (1996) realized that the silence category that was originally established in 1986 was much more complicated than originally thought and described. The silent learner did not necessarily take on the passive role in the classroom that was originally thought. In a science classroom, a silent knower might be someone who was processing information instead of someone who was not able to understand authority.

The Received Knower

**Received Knowledge: The Inner Voice:** Similar to the “Silent Knower”, this woman believed much along the same lines that there were people in authority and that they could dispense knowledge when it was appropriate. In the case of the received knower, there was not the lack of
hearing of the silent knower. The received knower had a dependency on words and focused on listening to everything that the authority figure had to say. Stanton (1996) believed that knowledge was received from authority figures. The received knower soaked up the information from the authority figure, was a good listener, remembered and reproduced knowledge and seldom spoke up or gave her opinion. The women were very uncomfortable with the thought that there might be more than one answer or more than one way to accomplish a task. The women would also have a problem with knowing where to start looking for information without guidance from the teacher. The student believed that the teacher’s answer was right because the teacher said it.

Goldberger (1996) believed that this category of knowing was not as simple or passive as initially described. Goldberger stated that the cultural meanings of respect to authority had not been taken into consideration in the original study.

The Subjective Knower

Subjective Knowledge: Personal, Private, and Subjectively Known: For this woman, the knowledge was very personal and private. In this category, the woman realized that she held some of the knowledge or information and that
the person in authority did not hold all of the knowledge. The women at this level actually began to become their own authority. Stanton (1996) found that the subjective knower began to look at her inner voice for truth and that her own ideas and opinions were unique. She spoke from her inner sources and from her feelings and experiences.

Belenky, Clinchy, Goldberger, and Tarule explained that the women at this level usually had witnessed a failed male authority. Our society taught us to put our trust and power in the male authority figure in our society. When the male authority figure failed, these women become outraged and moved themselves into the subjective knowledge category to begin thinking and questioning on their own.

Women at this level were aware of their ever-changing self and learned by listening and watching inwardly. These women began to realize that they had authority and that their opinion was valuable. In processing information in a science classroom, women at this level would begin to trust their own opinions. They tended to look at the teacher as a facilitator of information, not as an authority figure.

According to Debold, Tolman, & Brown (1996), the subjectivist's position was a way of knowing that was grounded in bodily sensations. They based their learning on
what felt right and they tended to turn away from authorities that were mostly males and turned to their own inner strength.

The Separated and Connected Procedural Knower

Separated and Connected Procedural Knowledge: The Voice of Reason: Women at this level were at an in-between stage. They were not yet comfortable with trusting their own feelings or opinions, but were not trusting of authority figures either. The women at this level needed to see things from multiple perspectives, intuition and integrating reason.

Women at this level operated on different frameworks and relied on the positive role of analysis (Stanton, 1996). She was suspicious of unexamined subjective knowledge and a careful listener. She aimed for accuracy and precision.

There were two levels of knowing at this level: the separated procedural knower and the connected procedural knower. The separated procedural knower separated between the knower and the object. She did not let personal feelings get in the way of making decisions. Women in science might gather information by making decisions based upon proof or evidence at this level of knowing. The women
in this category learned what it was that the teacher or authority figure wanted her to think and adjusted her thoughts accordingly.

The connected procedural knower preferred to be intimate with the knowledge and developed a true sense of understanding. The woman tried to make connections and build common experiences with others and with the knowledge and information she was processing. The woman science student learning science and making choices relied on others' knowledge and wanted to connect with this knowledge. The women at this level wanted to examine other people’s conclusions and answers to problems.

Procedural knowing was where students could evaluate evidence, judge conflicting claims and understand material from a variety of perspectives. Procedural knowing was more desirable than received knowing where students uncritically accepted an expert’s claim as true or subjective knowing where students confined themselves to exploring their own perspectives (Stanton, 1996).

In order to possess a total procedural perspective, the woman would exhibit or display part of both strands, according to Belenky et al. (1986, 1997). One of the strands might stand out over the other strand, but both strands were usually present in the women.
The Constructed Knower

**Constructed Knowledge: Integrating The Voices:** The woman displaying this category would integrate experience with thought and feelings. The woman was able to put knowledge together to examine her total being. She developed her own system of knowing and her own authority figures as well as her own voice to communicate this knowledge. This knower wanted to know why people thought what they did and how they came to certain conclusions.

Women at this level developed a sense of caring and understanding about the information that they were seeking. They were also concerned with talking to share their information instead of just talking to talk. The sharing of feelings and understanding actually resulted in new and deeper understandings.

Constructed knowers sought a two-way dialogue with both heart and mind and sought truth through questioning and dialogue. The women in this category spoke and listened with confidence (Stanton, 1996).

In connected knowing, women tried to embrace new ideas. They needed to know whether their thoughts could "mean something" to someone else, even, perhaps, an attentive stranger (Maher and Tetreault, 1996).
Since the original study done by Belenky et al. (1986), the authors had realized that they originally identified personality types. After revision of their work, they had changed to strategies for knowing rather than personality types. Some ways of knowing were more prominent or commonly used. Rarely was someone coded in just one knowledge category (Goldberger, 1996). The model identified the women at a moment of time.

Theories of Learning

These theories of learning helped to identify how women learn in a science classroom. Many of the concepts of these theories could be combined to provide valuable information to how women learn science. In constructivism, women brought epistemological assumptions into the classroom. The students accepted or rejected their teacher’s expertise and compared classroom material to their personal experiences and opinions. The women sought to understand and question how answers were arrived at and how knowledge was composed.

Vygotsky (1978) believed that embodiment and embodied knowing were developed through intersubjectivity and that cooperative inquiry developed through co-construction of knowledge.

Goldberger (1996) tied all of these concepts together and put the theories into a perspective applicable for all women in science. “How one knows is determined within the
array of the relationships that define the self. Meaning making is not a solitary pursuit, but is interactional and negotiable; that is, knowledge is co-constructed."

My research on the ways in which women process and absorb information in a science classroom would help to change women in being more effective and successful in the classroom. In so doing, the learning environment in a science classroom would be more conducive to women by allowing them to make connections and establish the relationships necessary to learn science.
CHAPTER 3
BACKGROUND, DESIGN, AND METHODOLOGY

Background

The case study was about women’s ways of knowing and learning science and how this related to success in a science classroom. Most questions of "how" were better answered through the use of case studies because the behaviors were not going to be manipulated (Yin, 1994). These case studies about women’s ways of processing information would be helpful in understanding the ways that women learn science. The study would also be helpful in breaking down some of the equity issues in science education. My goal was to expand some of the existing theories and report on women’s ways of knowing, and not to give a statistical generalization of these findings.

Interest in Women in Science

My interest in this area had evolved after eleven years as a classroom teacher in science. During this time, I had discovered that women had a different way of gathering and processing information. In the traditional science class, women did not use their unique methods to gather and process
information and were forced to adapt to the male way of thinking or not be successful in the classroom. My own awareness and attempts to be more sensitive to these issues had evolved into this case study.

Methodology

Case Studies

Stake (1994) defined a case study by interest in individual cases and not by the methods of inquiry that were used. Each case was specific and the behavior patterns of the system were a key factor in understanding the case. An intrinsic case study was a study that was undertaken because one wanted to better understand the particular case. The case itself was the main interest. An instrumental case was a particular case that was examined to provide insight into an issue or refine a theory. Case researchers sought out both what was common and what was particular about the case, but the end result regularly presented something unique (Stake, 1994). This research study involved both intrinsic and instrumental case study research.

The Subjects and Setting

The participants were tenth grade students from a suburban high school who were enrolled in an enriched integrated Biology and Earth science class. This was the second year of a two-year sequence that was required before any other upper science classes could be taken. The first
year of the program dealt with very abstract concepts in the areas of environmental, earth and biological sciences. The second year, which these students were currently a part of, involved more concrete concepts and the studying of concepts in more depth in the area of biological and earth science. Of this class of twenty students, nine were women. All nine of these women were asked to participate in this study. During the semester break, two women decided to drop out of the enriched program and enrolled in the regular section of the second year sequence. These women agreed to continue to be a part of the study.

The enriched section differed from the regular section by more in-depth study of topics, more individual work, more projects and a much quicker pace than the regular level of students. The expectations of these women were much higher than the women in the regular class. The women in the enriched program had developed ways of learning science that had allowed them to be successful in the science classroom.

Entry and Access

Following a discussion with the department chair and building principal, oral consent forms, as well as a letter explaining the purpose of the research, were sent home with the nine women in this study (Appendix A). There were nine women in the classroom and based on information from a pilot
study, additional information and initial observations, the women all seemed to have valuable information to share.

The students and teacher would remain anonymous and had agreed to participate in this study (see Appendix A). The teacher was a male and had been teaching in the school system for a total of five years in the enriched program. He had 15 years of teaching experience. The teacher was also interviewed during the study to examine what he perceived to be women's ways of knowing science.

Sample

The sample was a purposeful sample with the intention of gathering information that was appropriate for case studies (Patton, 1990). The study involved exploration and description of women's development of their ways of knowing science. The sample was purposeful in that the women were selected based on their success level of science and the way that they fit the model of Belenky et al. (1986, 1997), "Women's Ways of Knowing." This study involved exploration and description of women's development of their ways of knowing and processing information.

The high school was a large Division I school with approximately 1300 students in grades 9-12. These students had a high socio-economic status and had a large number of women in higher levels of science. Most of the parents in this school had professional backgrounds and were very
successful in their jobs. For the most part, the parents had high educational expectations for their children.

Using only women for my sample allowed me to break away from comparing women to men, as if male behavior was the norm. This would also allow for the data to be analyzed in light of women's reality as was expressed in educational preferences (Campbell, 1988). Also, trying to compare men and women usually led to noncomparable, either/or categories that did not allow one to realize how women really knew science (Brown & Gilligan, 1992).

Researcher Perspective

All students could learn science. Further, I believed women, given the appropriate learning opportunity could learn and be successful in science. I had been a classroom teacher for 11 years and had witnessed the unique and different processes that women used to gather and process information in a science classroom.

I had found that if the women in my class were able to make connections with the real world, and establish relationships with the objects studied, they were more likely to be successful in science. The connections that they made also increased their level of self-esteem and self-confidence.
Researcher Concerns

There were some limitations to using only a single case study to explore these issues (Yin, 1994). However, such a case could actually represent a unique situation and examine women's thought processes in gathering information.

Case study research emerged from one social experience, to mesh with another. The reported knowledge was socially constructed and the case study researchers assisted the readers in the construction of knowledge (Stake, 1994). Case study research also shared an intense interest in personal views and circumstances. These case studies were valuable in refining theory and suggesting possibilities for further investigation. They also helped in establishing limits of generalizability. However, the purpose of case study research was not to represent the world, but to represent the case (Stake, 1994).

Some of these students might have had me as a classroom teacher in the past, during their Year I science experience. I also knew and had worked with the teacher in this class. This type of situation might develop some insider/outsider tensions in the writing and analysis of data due to the familiarity of the situation. Bogdan and Biklen (1992), expressed this type of concern and suggested that the teacher might not view the observer as a researcher. However, the teacher in the class had been a researcher.
himself and understood the importance of research. Also, the study was not really looking at the teacher of this class, only the women.

Design of the Pilot Study

It was suggested that some information was gathered prior to the proposal being written (Bogdan and Biklen, 1992). This could be collected in the form of grounded surveys and other brief fieldwork. Qualitative research should involve writing detailed plans of the study after time spent in the field.

The pilot study took place during the fall of 1996. This pilot study was done at the same school, and included 26 male and female first-year students. The pilot study allowed the testing of some of the interview protocol questions and examined some of the women’s processing abilities (see Appendix B). The pilot study was done before the actual study and allowed focus on particular areas that might have been unclear previously. The pilot study also tested certain questions and helped to develop rapport with the participants as well as establishing effective communication patterns (Janesick, 1994).

The students were interviewed about projects that they had completed and a special inquiry project that was in progress. The students were asked where they obtained information, why they chose this information, and how they
used it. Their choices were then matched with their grades to determine what the "A" students used versus the "D" or "F" students.

The information collected from the pilot study provided some insights as to where women went for information and how they decided what to use. The results also allowed the development of some rough interview protocols as to how women might actually learn science and how that was related to the grades that the women earned.

Design of the Study and Data Collection

My design was based on participant observations, unstructured individual and group interviewing, participant written responses to open-ended questionnaires, document analysis of journals kept by the women, field notes and reflections and peer debriefing opportunities as data sources. All interviews were audio recorded, transcribed and given back to the participants for member checking. These are referred to as "data-collection traditions" by Bogdan and Biklen (1992). My data analysis, through the use of field notes and reflection, was an ongoing part of my research.

Beginning Data Collection

Data collection began by spending time as an observer in the back of the science classroom. How did the women in this classroom function and interact as a part of the normal
routine? With whom did they work? How did they handle and complete lab work? After sufficient time had been spent observing, the women participated in two individual interviews that were audio taped, a group interview, a lab experiment and journal writing.

**Initial Observations**

The initial observations that occurred helped me to explore the nature of a social phenomena of womens' ways of knowing and learning science. Atkinson and Hammersley(1994) believed that this was more important rather than setting out to try to test hypotheses about them. The data were not coded at the point of the data collection, rather a recording of the verbal descriptions and explanations of what was occurring in the daily routine of this science classroom. Denzin’s (1989) stages of observation were followed. The first step was to get familiar with the setting and the social organization of the classroom. After becoming comfortable with the setting, more focus could be devoted to the actual learning of the women in the science classroom. The observations also led to the development of interview questions.

**Purpose of Interviewing**

According to Scheurich (1995), the purpose of interviewing was to find out what was in someone’s mind, to access the perspective of the person being interviewed.
Lincoln and Guba (1985) described an interview as “a conversation with a purpose.” My interviews would actually help to confirm and explain what was witnessed in the classroom.

Kvale (1996), described seven stages for developing an interview. These include thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting. These steps were followed to ensure proper development of interview questions as well as using the interview questions to answer the research questions.

One of the most common and powerful ways used to try and understand our fellow human beings was through interviews (Fontana & Frey, 1994). The interviewer needed to play a neutral role and never interject his or her own opinions. The researcher must perfect a style of interested listening that rewards the respondent’s participation, but did not evaluate the responses (Fontana & Frey, 1994).

**Introductory Interviews**

The individual interviews took place in an empty classroom, at the high school, during the women's study hall. During the first round of interviews, most of the women seemed nervous about being interviewed and the use of the tape recorder. Most were also unsure about what
questions they would be asked and how they should respond. By the second round of interviews, the women seemed much more relaxed and seemed to open up more.

The first interviews were taped as a first step in data collection. All of the participants were informed in advance of the intentions of the study and understood the purpose of the research. The women were asked to reflect on how they gathered information for their science class and to share some of their memories of how they learned science (Appendix B).

Initial Analysis

I completed an initial analysis of the introductory interviews following their transcriptions and developed questions for the next interview. While I conducted an initial analysis, I asked each of the women to keep a journal (Appendix B), based on the types of activities they did in class and to reflect on how those activities helped or did not help them learn science. The journal was to bring attention to how they learn science. They were not requested to write in the journals on a daily basis, but only when they felt particularly strong about an issue. The journals were kept for approximately one month. The journals were then analyzed for patterns and themes that emerged from the writings.
Review of Documents

The review of documents according to Marshall and Rossman (1995) could help supplement participant observation and interviewing. Document analysis could be viewed as an unobtrusive method that could portray values and beliefs of the women in the study. The students daily notebooks were examined to verify the types of tests, labs and worksheets that the women had been asked to complete. A daily journal, reflections of their thoughts, would help to examine their values and ideas concerning learning and activities.

More observations, reflections and field notes followed the first set of interviews. The observations included the regular classroom set-up. Some days this involved lab work, other days lectures and projects. Observations were recorded in the form of field notes and observer comments.

Next Steps in Data Collection

The next step in data collection was to conduct the second set of interviews. These interviews were again tape recorded, but were conducted over the phone. The women seemed much more comfortable with this situation and offered more information and talked more freely about their experiences and situations. These interviews were also followed up with a preliminary analysis and more observations that helped me in preparing for the focus group interview.
Lab on Floaters and Sinkers

Prior to the focus group interview, the women in the class were asked to complete a lab on floaters and sinkers (Appendix B). The women participated in groups of three and were asked to verbalize their thinking process and describe how they were going about finding the answers. The labs were conducted in the hopes of generating ideas and patterns on how the women in this class went about solving problems and how group work could be beneficial.

Focus Group Interview

The last step in data collection was the focus group interview. I facilitated one focus group interview with the women over a one hour lunch period. The focus group interview was chosen as part of the data collection process in hopes that a group discussion would provoke memories and therefore cause the participants to reveal more about the ways that they learned science than they had done in the interviews. I also hoped to focus in on the common themes that had emerged from the interviews, observations and journals. The focus group interview provided another level of data gathering or a different perspective on the research problem that was not always available through individual interviews.
Interview Questions

The interview questions for the women were very open ended (see Appendix B) and allowed each of the women to respond freely. The focus group interview was audio tape recorded as well as videotaped. I felt that it would not be possible to distinguish nine different voices on an audio tape, so the video tape was used to help in identifying the women as they shared information. Much conversation was generated on how the women felt that they learned science and what was important in science. Only one participant did not comment during the one hour interview.

Open-Ended Questionnaire

At the end of the group interview, participants were asked to complete a short open-ended questionnaire (Appendix B). The purpose of the questionnaire was to draw out any additional information that they might have wanted to share, but were unable to within the larger group. All interview transcripts were given to the participants to be member checked and allowed for a chance for additional comments.

Interviews with Teachers

I did conduct two additional interviews with two teachers that I felt would be able to share some valuable information on how they felt these women learned science. The first of these interviews was with the current science teacher (Appendix B). I also asked him to submit the
women's grades that they had earned for the first semester. The grades would help me to validate the women's claims on how well they were doing this year.

The second of these interviews was conducted with the enriched science teacher from last year (Appendix B). All but two of these women had been in his enriched class the previous year. I asked him to share information on how he perceived these women as learners and how they responded in the classroom. I also asked him to share information on how he felt women learned science and some techniques that he has used to encourage women to be active participants in the classroom.

Time Frame

This study began in the Fall of 1996 after the first grading quarter ended and continued through the Spring of 1997. During the month of December, 1996, I observed the class at least 5-6 times. This allowed the students to get used to seeing me in the classroom and gave me a chance to see how the class was structured. In January, 1997, I began more a more intensive observations of the class. The class met from 2:20-3:10, Monday through Friday. Data were collected twice a week until enough data was collected to answer the research questions. My goal was to have most of
my data collected by the first of May. This allowed me to begin analyzing data and still be able to contact the women in the study prior to the end of the school year.

Data Analysis

Coding Process

The data was analyzed through a coding process adopted from Lincoln & Guba (1985). The data were also analyzed to identify any themes or patterns that were consistent throughout the study. Identifying patterns of thought and behavior were a form of reliability (Fetterman, 1989). The information found in Women’s Ways of Knowing was also used to help code the data. The women’s ways of knowing in this class will be identified as a silent knower, received knower, subjective knower, procedural knower, or constructed knower. The transcribed interviews, observations and journals were coded according to one of the five ways of knowing. Following initial analysis, a theming analysis was conducted. The themes were based on topics such as gender in science, preferences of learning styles and past science experiences. Qualitative researchers were more interested in accuracy of their data, rather than reliability (Patton,
The replication of the study would be nearly impossible due to different backgrounds of the researcher as well as the students in this study.

**Triangulation of the Data**

Triangulation of the data was very important in building and establishing trustworthiness. Triangulation through the use of individual and group interviews, field notes, observations, document analysis, and audio taping had all been used. Triangulating the data allowed the testing of one source of information against another to validate my findings. Subject review or member checking of the data had also been completed. After transcribing interviews and audio tapes, the data had been shared with the subjects to make sure that the responses reflected what they felt they were expressing.

**Audit Trail**

According to Morse (1994) an audit trail should be left in order to leave an adequate amount of evidence that interested parties could reconstruct the process by which the investigator reached her conclusions. The interview tapes were transcribed verbatim and I used the transcriptions as my data source rather than the actual audiotapes. Other categories of the audit trail included field notes with reflection, interpretations of observations.
and interviews, pilot study, journals and focus group interviews. All of these categories from the audit trail were included in the final version of the results and discussions. All components are open to review and evaluation.

Audit Trail

II# Introductory interview and page number
FI# Follow-up interview and page number
JE Journal Entry
PFGW Post Focus Group Writing
CT Current teacher
PT Past teacher
FN Field Notes
LAB Laboratory Activity
FGI Focus Group Interview

During the coding and theming analyses, the data were again identified within the data set, and by page number, where applicable. A matrix in the coding process, where I identified moments of various ways of knowing as identified through interviews and journals was presented below.
Table 1: Sample of coding process matrix

<table>
<thead>
<tr>
<th>Participants</th>
<th>Perspectives</th>
<th>Name</th>
<th>Subjective Knowing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maureen</td>
<td>Claire</td>
<td>important to</td>
</tr>
<tr>
<td></td>
<td>Katherine</td>
<td>Lauren</td>
<td>labs explore</td>
</tr>
<tr>
<td></td>
<td>Katie</td>
<td></td>
<td>working at own</td>
</tr>
<tr>
<td></td>
<td>Lauren</td>
<td></td>
<td>I have to get</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>interact (III)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>topics (III)</td>
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<td></td>
<td></td>
<td></td>
<td>pace (III)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>overview (III)</td>
</tr>
</tbody>
</table>

Ethics And Politics

It was my hope that the women involved in the study learned something about how they learn science. My interview questions and focus group discussion would be centered around these women’s ways of knowing. The answers and discussion should allow the women to learn something about themselves and what makes them successful in this type of learning environment. As a researcher, my hope was that the subjects in my study really did benefit by participating in my study.

Time Frame

October 1996  Pilot study with 1st year students

December 1996  Initial observations with year two
January-April 1997 Observations of females

January 1997 Introductory interviews
Researcher preliminary analysis

February 1997 Second interview
Researcher re-analysis

February-March 1997 Journals/documentation

Interviews with two teachers

April 1997 Focus group interview
Writing request following groups interview

March-April 1997 Further transcription and analysis of data
Follow-up individual interviews and transcriptions

April-May 1997 Completion of transcription
Completed collection of responses
Start of coding and theming analysis

59
May-June 1997  Write-up of study-first draft
June-July 1997  Revisions
Chapter 4
Presentation of Data

The nine women, as well as the two teachers that had agreed to participate in the study had been given aliases to provide anonymity and confidentiality. I would provide a brief description of each of the women in the study to provide background information on the type of student and learner that the women had displayed. The classroom set-up and daily routine would also be described as to help the reader get a feel for where this learning was taking place.

The data collected for this section had been gathered from my personal observations and experiences in the classroom, individual as well as group interviews with the students, journal entries, lab work and the interviews with their past teacher, Mr. Smith, as well as their current teacher, Mr. Hanes.

Classroom Description
Atmosphere

The classroom where the observations took place was brightly lit with individual desks in rows. The chalkboard
was in front of the room along with the teacher's lab table and desk. A computer was connected to a TV monitor that was mounted in the upper left corner of the room. The door to the classroom was slightly to the left of the TV. In the back of the classroom were six small octagon lab desks with stools and sinks at each one; a plant experiment with grow lights was set up in the back of the room. On the east side of the classroom, there was a row of windows that overlooked the tennis courts. During my observations, the temperature was cool in the room, and you could hear the motor running on the fish aquarium.

Desks

The desks were arranged in five rows, with five desks in each. Half of the classroom provided space for desks while the other half provided space for the lab area. At the start of this study, there were nine women in the class. During the time when most of my data was collected, there were only seven women who were currently enrolled. During the semester break, two of the women, Katie and Lauren, dropped out of the enriched class, and enrolled into a regular integrated science course. They both agreed to continue to be a part of the research study. There were 13 males and 7 females in the class.
The women were scattered throughout the classroom and sat in these same seats everyday. The classroom was very structured in that a normal routine had been well established and the students took their seats as soon as the bell rang. The students waited for instructions from Mr. Hanes regarding the agenda for the day.

Role of the Teacher

In this particular science classroom, the atmosphere was very structured in terms of methodology. The teacher was viewed as an authority figure and took control of the classroom. Based on my observations, most of the discussions were teacher generated with several male students contributing. Mr. Hanes took control of discipline problems, and was a facilitator in the lab area, guiding the
students to explore the answers. The content was based on the course of study, and followed a standard path through the curriculum.

First Observations

During my initial observations, it became apparent that the women in this classroom were very quiet and at times seemed almost non-existent. My first day of observations, Mr. Hanes was distributing a handout and had asked for someone to read the first paragraph. Mr. Hanes chose a male student, even though his hand was not up. He asked for volunteers to read the second, third and fourth paragraphs. Only the males volunteered, and only the males were called upon. The women in the class did not volunteer, or seem responsive or even interested in what was happening in the classroom.

Mr. Hanes then asked the students to get out a piece of paper and write down what the word “change” meant to them. All students in the class took some time, and then wrote a response. Mr. Hanes asked for volunteers to share their answers. Once again, none of the women in the class volunteered, or were called on for responses.

Mr. Hanes then proceeded to show a laser disk/computer program that showed different clips that represented change, and asked the students to write down the changes that they saw occurring. For instance, the students viewed clips
showing the sun setting, a storm moving in, and plants growing, to name a few. The clips were only 15-20 seconds long and were shown once. During the presentation, there were several occasions when the males in the room asked Mr. Hanes to slow down or to repeat the clip. The comments were blurted out, without hands being raised or being acknowledged for their requests. The women never made any comments even though their faces displayed confusion and puzzlement. I wondered how the women felt trying to come up with their own answers. I wondered why they had not asked any questions.

During my initial observations of several days, I saw that there were several males who seemed to dominate this classroom. The evidence for these males as a dominant factor in the classroom, came from classroom observations, interviews with the women, as well as comments from Mr. Hanes during his interview. These few males blurted out answers, asked questions to get the teacher off track, as well as took control of most discussions. These dominate males might have been enough to intimidate the women in the classroom, especially if the women needed time to process answers and to try to make connections to what was happening in the classroom, as the literature had stated.
Mr. Hanes' Perspective

After my initial observations, I was able to interview Mr. Hanes on the lack of participation of the women in his classroom, as well as the behavior of the dominant males. I explained to Mr. Hanes that the women in his class seemed very quiet, and did not seem to participate verbally in the class. I asked if this had been the general trend all year, and if he had noticed any changes according to subject mater.

Mr. Hanes: I must preface the responses to your question by acknowledging the somewhat unique nature of my 8th period enriched integrated science class. The class is dominated by two or three overly eager, hyperactive gentlemen who feel that they have a right to vocally express every feeling or thought that they have without stopping to think and decide if what they have to say is worthwhile to the rest of the class. This creates an environment that makes it difficult for the rest of the class to have an opportunity to express themselves. This situation calls into question the policy of having students self-select for the enriched track, as I would characterize the behavior of these somewhat boisterous young men to be something other than behavior that I would traditionally associate with enriched students (CT 1).

The other 10 males in the class were also silenced by these dominate males, but not to the degree that the females appeared to be silenced. My observations showed that these males would ask questions occasionally whereas the females would not ask questions.
In terms of the women being quiet, Mr. Hanes agreed that:

the women are very quiet in 8th period. This has been the case for the entire year. I haven’t seen a great deal of difference in participation regardless of the subject matter. I feel that the lack of participation of the women is a direct result of the handful of boisterous male students who tend to dominate the class with voicing their comments (CT 1).

The women in the science classroom had all been successful in science and had chosen to take the enriched track of Integrated Science. How were they able to learn science and be successful in a classroom such as this? Were the women intimidated by these male students or just generally shy? The women in the study provided the answers to these and other research questions.

Emerging Patterns and Themes

Throughout my research, various patterns and themes had emerged from the data. These patterns and themes had been used to code the data. Some early themes that emerged were class participation of these women as well as how they obtained information. These early themes helped me to guide and shape my research efforts. By the end of the study, many more themes and patterns had emerged and were coded in the data.
Katie

Katie was one of the two women in the study who had not taken enriched science the year before. During her freshman year of science, she was a very diligent student and received the highest grade in her class. She was not intimidated to ask questions or to state her opinion. At times she was somewhat bored in her regular science class and decided to spend her sophomore year in an enriched class.

The usual pattern of science course work involved two years of the integrated science program, before moving on to any of the other sciences. The students as freshmen could self-select into a regular year one or an enriched year one integrated science course. Most students at this school enrolled in the regular section; only two sections of enriched science usually ran each year compared to 18 regular sections. Most students who took the enriched track their freshmen year would continue to take enriched classes their sophomore year. Katie was an exception to this norm.

After the first semester in the enriched track, Katie decided that the course was just not for her and decided to drop back into a regular track course of the same subject.
Katie explained, I switched because I really did not understand what Mr. Hanes was talking about. He would say stuff and it just wouldn’t make sense to me. If we were talking about something at the end of the period, and the bell would ring, we would never pick back up on it the next day. Mr. Hanes would just start on something new the next day. I also did really bad on tests and he taught mostly through lecture. He would have us take notes, but he wouldn’t write anything down on the board. He would write the names of things down on the board, like mitochondria, and then just talk about it. I didn’t know what I was supposed to know (II 2).

Katie had trouble making connections with what she was learning in Mr. Hanes’ class. This in turn caused her to find the tests difficult.

“The tests were multiple choice, and there was some true/false, and usually five essay questions. They were so hard. He would pick out the littlest things and expect us to know them. When we asked him about the questions that we hadn’t talked about, he said that he expected us to read about it” (II 2).

Katie then moved to Mrs. Jones’ regular integrated science classroom. She felt much more at ease in her classroom because Mrs. Jones gave them more time to finish their work and to process information. Mrs. Jones could deliver the information in such a way that Katie could understand it. Mrs. Jones also moved through the curriculum at a much slower pace, which allowed Katie to grasp and process the information. Katie’s success in her new class could be attributed to an easier curriculum as well as the teaching methods displayed by Mrs. Jones.
Confidence

Katie believed that she could learn science but in order to do so, she needed to be able to have her questions answered. She was also afraid of feeling dumb in asking Mr. Hanes questions in her enriched class.

If I ask Mrs. Jones a question, I don’t feel as dumb because his (Mr. Hanes) is an enriched class and hers is not. It’s like you can ask pretty much anything that you want. Sometimes, Mr. Hanes would get mad if we like asked questions. That really bothered me because he’s supposed to have time for questions. If you don’t understand, how are you supposed to do the work? You have to have time for questions (II 2).

Past Science Experiences

Katie enjoyed middle school science because she got to work at her own pace.

We would have a lab book and we just got to work, however long we need for one thing, that’s how long we got (II 1).

She remembered her first memory of science as being in 5th grade when working on a battery and bulb science activity. She had no recollection of science earlier than 5th grade. Katie also remembered 8th grade science as being fun and she shared an example.

We did this one thing where we had to put acids and bases down a tube and they had milk jugs. I don’t know for sure what it was, it was like a waterfall or something. We also did a lot of stuff with feedback and response as well (II 1).
Authority Figures

Katie had all women science teachers up until Mr. Hanes. With Mr. Hanes, her previous ways of knowing science and making connections had changed and left her feeling very unsure of her science ability. Katie recognized that the class just did not work for her and she needed to make some changes. This was one of the reasons she elected to drop into a regular science class at the semester break.

If Katie did not understand a lab question or procedure she would usually ask other classmates before going to the teacher. If the first friend did not have the answer, she would proceed to ask another friend. Katie did remember in middle school asking the teacher for help when she was stuck on a problem.

My teacher in middle school was really, really nice. I didn’t have a problem at all with asking her questions. I asked her a lot (II 1).

Katie’s reliance on her friends to help her when she had questions had developed since she entered high school. Katie did not feel as if her high school teachers could explain the information well enough for her to understand. Even though Mr. Hanes was Katie’s first male science teacher, she did not notice a difference between men and women in terms of her learning science (II 1).

In doing homework, Katie also felt very strongly about going to her friends to get the information that she did not
understand. When asked why she would go to her friends, she replied,

Because they will give me the answer, I don’t have to think about it (II 1).

Katie did not use her textbook to find information about questions that she might have because she found the book very difficult to understand and confusing.

When Katie found that she could not gain an answer from any of her friends, she would then proceed to ask Mr. Hanes. I asked her why she would ask Mr. Hanes and she replied, “because none of us knew, and he’s the teacher, so he’s supposed to know” (II 1).

Katie trusted that the information that her classmates were giving her was accurate. In a lab, or on a homework question, Katie would usually write the answer down without really questioning where the information came from.

I would just write the answer down unless it sounded really off the wall. Then I would ask the teacher. I would do the same thing whether it was a male or a female (II 2).

As I observed a lab that Katie and Lauren worked on together, Lauren gave an answer and then asked Katie if she agreed. Katie replied yes, wrote the answer down and was ready for the next step. I asked Katie if she really understood where Lauren was getting the information. Katie said that she really did not know where Lauren had gotten the information. Lauren then proceeded to go back through
her procedures to explain to Katie how she had arrived at that answer. Katie did not feel that she needed to ask Lauren to explain, she just believed that what Lauren was telling her was the truth.

**Learning and Learning Science**

Katie defined learning as “taking information in and processing it, making it mean something” (FI 1). Katie learned science by “making a lot of connections, like thinking a lot and connecting things” (FI 1). Katie would rather work by herself as opposed to a group. “I’m more likely to get things done by myself than in a group” (FI 1). In her opinion, group experiences had tended to slow her down and hold her back a little.

Katie was also able to learn science better now that she was in Mrs. Jones’ class this quarter.

This quarter is like more hands on and stuff than it was before. Before, we would just take notes and none of the stuff would make any sense. Now, since we do labs that are practical, you learn stuff. We did some impractical labs in Mr. Hanes’ class. The labs that we do now are more interesting. For example, the digestive system and stuff, in my enriched class, we would just each have a system and we taught our class and we learned it in one day. But now, in our classroom, we’re doing labs to find out about what’s happening, where as in our other class we sat there and listened to people talk, if you chose to listen (FI 1).
Good Science Lesson

Katie described a good science lesson as one that had plenty of hands-on activities to work on.

Hands-on stuff is much better than just sitting there and listening to a teacher talk (FI 1).

Katie went on to describe a lab that she had just completed in Mrs. Jones’ class.

The last lab that we did, I really like that one. We’re learning the digestive system and we were doing things with amylase and trypson to see how the stomach digests things. We had different components that were added to trypson and stuff to see if it would digest the things. Things like that are pretty neat (FI 1).

Bad Science Lesson

A bad science lesson to Katie was one in which you were just sitting there and taking notes. “I just stop paying attention when I have to take notes” (FI 1). Katie indicated that she believed that taking notes to get some background information before beginning activities was important though.

I think that when the teacher explains things, it helps me, but not in great detail or anything. It’s okay to explain the lab for 5 or 10 minutes and then let us do it. (FI 1).

Good Science Teacher

A good science teacher, in Katie’s opinion, would be one that would let the class work at their own pace. They
also need to be “nice and smart”, and take the time to answer our questions when we had them.

**Bad Science Teacher**

Katie thinks that a bad science teacher would not want or care to take the time to answer questions. A bad science teacher would also

make us take notes the whole time. I hate when teachers answer our questions with a question. If they did that, I wouldn’t like that (FI 1).

A science teacher that was not understanding or patient, the opposite of a good science teacher, would also fit Katie’s description of a poor science teacher.

**Lauren**

**History**

Lauren had taken the enriched track as a freshman and decided to continue on that route her sophomore year. During her freshman year, her teacher, Mr. Smith, had very positive comments about her learning science.

Lauren presents herself to be more of an aggressive person than the other women in the class. She would go home and talk to her father about what she had learned in class and they would talk about different things. Lauren would come into class the next day and ask me questions to try and stump me. If I answered the question, she would tell me that I wasn’t supposed to know that. She was very willing to ask questions in class (PT 1).
After the first semester, Lauren decided that the enriched class was just not for her. She decided to join Katie and drop out of the enriched class and enroll into the regular section of the integrated science program. She also entered Mrs. Jones’ class with Katie during the same class period. When asked about her decision, Lauren responded:

The most important reason that I dropped the enriched class is that it just became more work than I could handle. I have priorities in other places and the last four weeks of the quarter, there were three projects to do and they were all research projects. They all required presentations and on top of all the other classes and the end of the quarter things, it just got to be too much (II 2).

Lauren also had much difficulty in understanding the text-book in her enriched class. She found that it was not a valuable resource for her in helping her to make connections. In Lauren’s opinion, the text was written at a college level, and she had no way of understanding the information in the book. The textbooks for the regular class were much easier to understand.

Lauren had a B average in the class prior to the end of the semester but ended up working really hard as the semester came to a close.

I thought that Mr. Hanes knew that I was dropping, and I didn’t want him to think that I was taking an early vacation. I worked really hard and ended up with an A (II 2).
Lauren also struggled with the type of tests that she was given in her enriched class. She believed that she did not do well on essay tests because she was much better at talking her way through an answer rather than writing” (II 2). “The multiple choice tests are very difficult because the questions are misleading. I’ve taken his take home tests to academic assistance before and we’ve both sat for the entire period trying to think what the question means. Different interpretations could lead to different answers (II 2).

Lauren was the type of student who liked to ask questions and felt free to question ideas or knowledge that she did not understand. Lauren felt that the enriched class did not allow her to ask questions that would help her to make the necessary connections to be successful in the classroom. By entering Mrs. Jones’ class, Lauren was able to ask questions and make her connections.

Lauren described Mrs. Jones as being very patient and she tried to make connections in the classroom.

If someone doesn’t get something, Mrs. Jones will explain it in a different way. She is very clear in how she explains; she is always making diagrams and writing stuff down.

Lauren was also able to provide some actual examples of what she was talking about.

Right now we’re doing cellular respiration and Mrs. Jones is making connections with the food we eat and how it is used in our bodies and what the effects are(II 2).
By providing Lauren with these connections, she could understand why the lab was important as well as understand the personal applications.

We’re not just doing labs and lab reports. With Mr. Hanes, I felt that we were just doing labs or just learning things with no connections between the units. I just didn’t see any real life applications. Last year Mr. Smith was able to make those connections to what we were studying (II 2).

Lauren was much more comfortable in Mrs. Jones’ classroom. She felt that she could ask questions and receive answers that made connections and learning real to her. Lauren was also taking Chemistry this year, and by dropping to the regular track she had much more time to focus on that subject as well.

Confidence

Lauren had a great deal of confidence in herself when it came to learning science. She shared an example with me where she had to miss a day of Chemistry and was able to grasp the information on her own. She was also a student who liked to think for herself and found herself thinking of ways to improve lessons and labs.

In our regular science class, we conducted an experiment pertaining to the circulatory system. We tested our heart rates at rest and during moderate activity. This was kind of fun; however, what we did for moderate exercise was just things like side bends and arm swings, hardly what you would call moderate. If I could do it again, I would replace those exercises.
with light jogging, and then run or sprint for vigorous exercise to get a more accurate picture of how my heart rate changes (JE).

Lauren’s confidence in science was also demonstrated in the lab exercise that I observed. In this exercise, Lauren and Katie were to verbalize their thoughts as to how to solve the problems in the lab. At the start of the lab, Lauren took charge by explaining to Katie how they do labs in her Chemistry class. She then asked Katie whether she “wanted to read the directions or actually do the lab” (Lab 1).

Later, in the focus group interview, with all of the women, after I asked the opening question, the rest of the women looked at Lauren and said, “Take it away Lauren” (FG 1). This provided evidence to me that the other women in the class viewed Lauren as confident as well as a leader in science. Also in the focus group, Lauren answered most of the questions first, with the other members of the group following her lead. Lauren was responsible for generating most of the discussion in the interview.

Past Science Experiences

Lauren’s first memory of science was in sixth grade. Her sixth grade science curriculum was based on the BSCS framework. Lauren really did not like this curriculum.

I was kind of bored, but I do remember something like a play that we did involving really old scientists (II 1).
When Lauren was asked to elaborate on the boring part, she stated that

it was right out of a book and there seemed to be no creativity to it. It’s not like third grade science where you could do experiments, this was too defined” (II 1).

Lauren also remembered a time in fourth grade where she did a science experiment with celery and colored water.

The colored water eventually colored the veins of the celery too (II 1).

The hands-on activities that Lauren had experienced in her earlier years seems to have left the biggest impression on her science learning.

**Authority Figures**

Lauren believed that the teacher was an authority figure, but was not the only authority figure in the classroom. Lauren was usually the friend that her classmates would ask if they were stuck on a question. Lauren would also ask a friend if she was stuck on a homework or lab question. However, she usually wouldn’t ask more than one friend.

I might look back in the book one more time, but I don’t understand the book so that’s not always a help. I would probably ask Mr. Hanes the next day (II 1).

Lauren did not necessarily feel comfortable approaching Mr. Hanes, but

it gets to a point where I don’t really care to spend any more time on it.
Lauren did not take the answers that she received from her friends as accurate. Even though she did not have the answer, she found herself going through and re-working the answers that her friends gave her to see if they checked out or not. She does not take the voice of her classmates as the authority.

Lauren had no trouble participating in class when she was in the enriched class. She talked a lot in class and was not afraid to ask questions. Lauren did admit that there were some very pushy males in her class, but that they did not keep her from asking questions.

What bothered me was that Mr. Hanes would joke around with the guys and answer their questions, but I felt that when I asked a question, like ‘I don’t understand’, Mr. Hanes would ask me, ‘what’s there to not understand?’ He would then go back to joking with the guys (II 1).

Learning and Learning Science

Lauren defined learning as “gaining knowledge” (FI 1). Lauren indicated that she learns science by “reading, listening and experience” (FI 1).

Over the summer, I went on the field studies trip out west. I learned a lot about the desert life just because I was out there. We did a lot of hiking and for practical reasons, you had to know which animals were which and which insects were which and which ones to stay away from. Because I was right there, there’s a reason to know it. I can still identify a scorpion and all sorts of different organisms out there (FI 1).
Lauren did not learn science through lecture and overheads. Her journal entries indicated that she was much more excited about learning if she could actually do something hands-on. She was much more likely to retain the information if she could see it happening. In one of her journal entries she stated,

> today we started to cross-pollinate our fast-plants. This fast-plant project is part of our final. I like that because there is no written test to cram for. I also really like watching the changes occur in the plants. Seeing is believing (JE).

More evidence that Lauren liked to learn from hands-on experience is found in her post group interview follow-up.

> I wish that we took more field trips. It would be nice to see real world applications outside of the classroom. I remember we went crayfishing in 5th grade for our crustacean unit. That was fun (PGFI).

Lauren was much happier with the textbook that she had now in her regular class. She found herself using the text much more than she did in the past.

> "The text now is much more easier to understand and I feel it is better organized. The text also has real world applications. It relates what we learn about the body systems to things like athletic performance and day to day life effects" (JE).

In describing her ideal learning situation, Lauren would have one where

> it wouldn’t be so tense and expected to be in their seats as soon as the bell rang. The teacher would be very patient and the
experiments would be fun and there wouldn’t be a lab report every time there was a lab. Everyone started dreading the labs because they knew there was a lab report to come (II 2).

**Good Science Lesson**

Lauren described a good science lesson as one in which there was a small amount of spoken introduction by the teacher at the beginning of the lesson. After that, it would be important to have an active experiment where everyone is involved. Kind of hands-on things (FI 1).

Lauren believed that closure at the end of an activity was important in helping to make connections. She remembered that Mr. Smith from last year would use some “really good visuals” on a laser disk.

He really knew what he was talking about. He wasn’t just reading off a prompt or the words that go along with the filmstrip (FI 1).

**Bad Science Lesson**

A bad science lesson, in Lauren’s opinion would be one where it was “just led out of a textbook and kind of sterile” (FI 1). This would include mostly lecture with very little hands-on and interaction with the materials in the lab.

**Good Science Teacher**

A good science teacher was somebody who “is enthusiastic and creative and does their fair share of the
work" (FI 2). This type of teacher would not use a “lot of
textbook stuff and not make us do a lot of the work”. A
good science teacher would really “lead the lesson” and do a
“good job of describing the details and stuff”.

**Bad Science Teacher**

A bad science teacher would be one who would not be
able to answer Lauren’s questions or explain materials to
her in a way that she could understand. Lauren also
believed that a poor science teacher would be somebody who
was

pretty dull and boring and isn’t prepared and
doesn’t know how to put different slants on
things (FI 2).

**Nicole**

**History**

Nicole was the other woman in the study who had not
taken the enriched course her freshman year. Nicole was
very active in class as a freshman and constantly
volunteered to answer questions and participate in
demonstrations. She was very energetic in class and always
had information to share with the class.

Nicole was a leader in the classroom and took charge on
many group projects. She took much pride in her work and
spent long hours making projects the best that they could
be. Nicole was very enthusiastic and excited about science. She received one of the highest grades in her class as a freshman and decided to challenge herself by taking the enriched track as a sophomore.

Nicole indicated that she realized early in the year that the enriched track was much more difficult and that she had to work harder to achieve good grades.

Science had always come really easy to me. I’ve always loved science and I don’t tend to think of a B as average. A C for me is failing and I was getting some Cs in the enriched course. I couldn’t understand why I was failing at something that I love so much and was good at. I guess I realized that not everything comes easy to me. I got kind of discouraged at first, but I worked really hard and got a B+ on my midterm and my one project. That shows me that I can make improvements. I tend to really work on that subject if I am struggling and try to get it as good as it can be (II 2).

Confidence

During my many observations in the enriched classroom, Nicole was very quiet and withdrawn. She did not participate in discussions, nor did she raise her hand to ask questions. Her energy and enthusiasm returned when she was participating in a lab with the other women in the class. Nicole did not believe that her quietness had anything to do with the dominant males in the class controlling discussions. She defined her quietness in terms of not taking the enriched tract the previous year.

Everyone else in the class has taken enriched before and so it’s kind of the
intimidation factor of well, whether I’m wrong or not. I think that sometimes that guys tend to make a bigger deal about it if you are wrong. At the beginning of the year, I never asked questions and now I’m getting more comfortable with it. I think that’s a lot of it, and I just think that a lot of the girls in the class are shy. I don’t tend to ask Mr. Hanes questions because I don’t tend to get the answers back real clearly. He uses big words and stuff and I don’t tend to get the message very well (II 1).

Past Science Experiences

Nicole had pretty much been around science her whole life. Living on a farm and seeing how things interact had made a valuable impact on Nicole’s life. “It’s easiest for me to learn from hands-on experiences” (II 1). Her first memory of science was also experienced on the farm as early as preschool. She could not actually pinpoint an exact time in her life when she remembered learning science because she was always around science.

Nicole did not really remember science all that much in her elementary school. One incident she did recall was when we did tadpoles and crayfish and stuff like that. We also did the solar system. The tadpoles were fun to watch through their whole stages. In second grade we had chickens and eggs and watched them come out. Also, butterflies in the second grade, just pretty much everything that I remember that was pleasant had to deal with animals (II 1).
Authority Figures

Nicole indicated that she viewed an authority figure as "anyone that she knows that might know the answer". This could range from friends, to her teacher, parents or professionals in the business field. On her homework assignments, she was likely to go to her friends first to see if they have the answer.

If her friends did not have the answer, she was more likely to go to the academic assistant or to her dad.

I used to go to a teacher, but Mr. Hanes, I don't tend to understand as much.

It was important for Nicole to be able to make connections in order for her to understand something.

I need more of an analogy of like this compares with that. Mr. Hanes does not use very many analogies and he'll say that it is this way because and start explaining stuff, but I don't understand that either, so I don't really get the idea (II 2).

In working on in-class labs, Nicole was more likely to go to Mr. Hanes for help if none of the other lab groups had the answer. She would ask Mr. Hanes because

he is the one that gave the assignment and he should know the answer (II 2).

Even when her friends provided her with the answer, Nicole wrote down the answer and then thought about it.

If the answer really didn’t make sense, I would then go to another source or look into my book further to find it (II 2).
If there was any question in Nicole’s mind whether the answer was correct or not, she would write it down and ask someone about it later to make sure that it is right.

**Learning and Learning Science**

Learning for Nicole was being able to recall the information that you remember and being able to put it to some kind of use. You can do something and turn it in and get an A, but if you don’t remember it a week later, it wasn’t really worth learning (FI 1).

Nicole learned science best from hands-on experience or doing stuff. I get more out of labs than I do the lectures, and the videos, sitting still and watching. I would rather be doing it myself. Figuring out why that happened the way that it did. More of an inquiry type of learning (FI 1).

Concept maps also helped Nicole to make connections in her learning of science.

By doing the concept maps, I am seeing the relationships between the things that we have been studying. I think that this would have helped earlier on (JE).

Nicole also enjoyed working on interactive CD-ROMs. Her class spent four days in the computer lab on a self-directed worksheet and CD-ROM. The first day in the lab, Nicole commented on how this was a good way to learn information, but found herself getting bogged down in all of the questions. She was working with two other people on the computer and commented on day two that it was difficult to
do an activity such as this with three people. By the third day in the lab, Nicole was becoming bored with the activity and felt that there was too much to get through before the deadline. All we are going to get done is answering the questions; we can't really process the information (JE).

The fourth day of the lab, Nicole's group hurried through the information, and she commented that she could not really remember the end of the CD-ROM because she hurried through it.

The following day, the class was tested over the information that had been presented to them on the CD-ROM and worksheet. Nicole indicated that she felt that the test was very hard because she could not really take the time needed to learn it well enough for the test. She had to just hurry through it to get it done.

**Good Science Lesson**

A good science lesson for Nicole was one that probably everyone wants to do and you come to class ready to do it, rather than dreading coming to class. After the lesson is over with, you're still thinking about it (FI 1).

An example of a lesson that Nicole would be excited about coming to class would be one where there was lab work involved. Something like identifying rocks, not just sitting in her seat all period.
Bad Science Lesson

Nicole described a bad science lesson as one in which you would "dread coming to class".

You just try to get through the period, blow it out of the way and forget about it. I would dread coming to class for a movie or knowing that I had to sit and take notes all period (FI 1).

Good Science Teacher

Nicole indicated that she believed that a good science teacher was one who could explain an idea in several different ways. This type of teacher would not blame the students if they did not understand something, but the teacher would take the blame, understanding that they are not getting the point across to you in the "right way".

If the whole class does not understand, that should be telling the teacher something (FI 1). A good science teacher would show you several different ways so that way you could put the information together for yourself.

For Nicole, a good science teacher would have to be someone who was personable with their students". They shouldn’t just "hand out dittoos, collect them the next morning, and hand out more dittoos. You have to be able to actually tell that they care about you and your learning (FI 2).

Nicole also felt that there should be a strong interaction between the teacher and the student in order to produce a positive learning atmosphere. This type of teacher then would be able to make the necessary analogies
for Nicole to make connections as to why she was learning the material that she was.

If I think that a subject doesn't have any meaning, or that it's not going to affect my life in any way, I don't understand. Why bother learning it? If I know that I'm going to need it for something else or I need that to do something fun, then I like it (FI 2).

Bad Science Teacher

A bad science teacher would be someone who used a lot of big words that I don't understand. Just kind of rambling on and on and you just think, why am I here? (FI 2).

Nicole also believed that a bad science teacher presented information in such a way that she was unable to get anything out of the information.

Claire

History

Claire had been enrolled in the enriched section the previous year and had been very successful. Mr. Smith described Claire as a student who had "good work ethics and pretty good grades" (PT 1). Her success in her science in middle school had given her the confidence to be successful
in high school science. Claire was able to process information and know what was important in terms of being successful.

In the classes where I had observed Claire, she was very quiet and seldom took notes. In a lab situation, she worked very hard to make sure that the labs were completed and helped to keep her group on task. I asked Mr. Smith about Claire’s actions in his year one course. He shared with me that Claire “was very quiet in his class and wouldn’t raise her hand a lot”. However, if Claire had a question, she would “come up to me on a one on one basis quite readily” (PT 1).

When I asked Claire about being quiet in class, she told me that she did not usually ask questions in that particular class because

I don’t have any questions to ask. I don’t feel uncomfortable answering questions. I don’t know why I don’t answer questions (II 1).

I also asked her if she was called on to answer questions or if she was able to sit and not be an active participant in discussions. Claire did not get called on in class.

Usually he calls on the guys, probably because they are so gung ho about answering in the first place. Sometimes if he called on me, I may not be able to put the answer together real quick and that’s something that I have a problem with. I always have a problem getting a
clear answer out so he’ll understand it because sometimes he doesn’t seem to see everything the same way that the students do (II 1).

Confidence

Claire was very confident in her ability to do science. Her sharing with me that she did not ask questions based on the fact that she did not usually have questions, showed the amount of confidence that she had in herself. During my observations, Claire also took very few notes during lectures and discussions. She was confident in her ability to remember and know what was important.

Even though Claire was very successful in science, she did not really like science that much. I’m more oriented toward English and history rather than math or science. Science comes pretty easy to me, that’s why I take the enriched course (II 1).

Claire’s grade in the enriched class was an A. Her future plans included wanting to pursue art or art history.

Past Science Experiences

For Claire, her science experiences in elementary school were not worth remembering.

I don’t remember anything at all about science in elementary school. I don’t remember it at all except that we used the textbook and we didn’t do any experiments, it was just straight out of the book. It wasn’t very fun or entertaining for an elementary school person (II 1).
Claire remembered more about her middle school science experience because they did "a lot more labs and hands-on experiments". Claire liked this much more because of the actual hands-on and seeing the results of experiments.

When asked about her first memory of science, the only thing that came to mind was in elementary school.

We were talking about pulleys or something. That doesn’t even seem to be science now, I don’t know (II 1).

**Authority Figures**

Claire did not have any trouble finding information for her enriched class. If she did have trouble with a question, lab or homework, she would ask Mr. Hanes.

Mr. Hanes would know what was going on, so if I would miss something or if I didn’t read something correctly, he would be able to tell me.

If Mr. Hanes was busy or unavailable, Claire would ask a classmate or a lab partner for help.

A classmate might have been listening when I wasn’t or might have learned something or heard something that I might have missed (II 1).

Claire indicated that she viewed Mr. Hanes as an authority figure in the classroom and that he knew for the most part what the answers were. There were times however when Claire questioned some of the information that Mr.
Hanes provided to her and the class. Usually Claire would have just spoken to him and told him that she did not really understand what he meant.

In terms of approachability, Claire found Mr. Hanes very approachable and did not hesitate to ask him questions.

Even though he loves science so much that he doesn't understand why some of the kids in the class don't keep it as a first priority. So in that situation, in that case, sometimes he is a little unapproachable. I guess you have to overlook that since he is a science teacher (II).

When Claire was working on a lab and her group was confused about a procedure or an answer to a question, she found herself checking with other lab groups. Claire did not necessarily believe that the other groups were an authority on the topic, but that they might have learned something that she overlooked. She will always do a "self-check" on any of the answers that they provided her.

Learning and Learning Science

Claire defined learning as

acquiring information that one finds important and that information stays with you (FI 1).

Claire learned science best by

paying a lot of attention and really listening to everything that is being said and taking notes. I try not to disregard any information because it could be important (FI 1).

Claire also indicated that she viewed herself as an auditory and a hands-on learner. She felt that in science
class it was easier for her to understand something if she could see what was going on as well as to listen during a lecture and a lab. Both ingredients would be necessary for Claire to learn science.

Claire’s journal entries also reflected additional ways that she was able to learn science. She enjoyed the computer/CD-ROM activity on Plate Tectonics because it was hands-on and it was a change from the usual lecture. The computer simulation provided the concepts in a way that were easier to understand” (JE).

During a unit on geologic processes, the class was asked to make group presentations on a particular geologic process. Claire did not feel that the group presentations on geologic processes were helpful.

There has got to be a better way of doing it, no one is able to understand the concepts (JE).

Along these same lines, Claire felt that the videos that they watched in class were very “boring”. She could not gather the information that she needed from a “long and boring video”. When Mr. Hanes made her take notes off the video for homework points, Claire was able to gain more information because she was forced to pay attention.

**Good Science Lesson**

Claire said that a good science lesson, where she would get the most out of it, would be one where there was
a lecture, short lecture, but describes the purpose of something that we're going to do. I also need to know what we will learn by it and how it affects things.

Claire needed the lecture followed by a lab or activity that showed her how things work and provided her with a hands-on experience.

**Bad Science Lesson**

Claire indicated that a bad science lesson would be one that did not provide her with any direction in terms of what she was going to be doing.

A bad science lesson would be one where there was not a good introduction. Without the background information, people in the class, including me, wouldn't understand what we were supposed to be doing because we didn't know what it was in relation to (FI 1).

**Good Science Teacher**

In Claire's opinion, a good science teacher needs to be patient as opposed to English or something else. I think that science takes a little more to grasp the concepts than in other subjects, so the teacher in science needs to be more patient (FI 1).

Claire also stated that a good science teacher would use plenty of examples to help get their point across. The visual as well as the auditory learning helped Claire to understand what she was supposed to be learning.

**Bad Science Teacher**

A bad science teacher for Claire would be one who "doesn't have much patience with the students". Claire gave
a specific example in terms of students who have other priorities outside the science classroom.

Teachers who think that their students could only be concerned with what is going on in their class, has to be more open minded about what is going on and try not to overwhelm the students with the assignments (FI 1).

Maureen

History

Maureen had been successful in science during her middle school years and that was one of the reasons that she chose to take the enriched course as a freshman. In the observations that I made of Maureen in her second year of the program, she appeared very quiet, and, for the most part, she kept to herself. I did not witness her asking questions or participating in discussions. Mr. Smith, her last year’s teacher, commented that Maureen would come up and ask him questions if she had any. Most of these occasions occurred on an individual basis though, and not many questions were asked out loud so that her classmates could hear.

I also found that Maureen was very well read in terms of women in school and the lack of women in science. In fact, we had read several of the same books and provided
some enlightening conversation. Maureen commented that after reading *School Girls* (Orenstein, 1995) she started looking at the way that she behaved in class.

It’s something that you don’t even realize. I’ve realized that boys will raise their hands and shout out answers, and don’t really care if they are wrong or not.

If Maureen felt that she might be wrong on an answer, she would “rather keep quiet than to say a wrong answer” (II 2). This type of thinking really bothered Maureen and she wished that “she didn’t think this way”.

Maureen did not remain quiet in all of her classes. In talking about her enriched experience from last year, she was much more willing to ask questions.

We had a smaller class and I think that even though a lot of times we didn’t have as many of the boys who are obnoxious, we were all sort of friendly. When Mr. Smith would give a lecture, it would sort of be more of a conversation where we would ask questions. I was definitely more comfortable I think in that situation. I remember asking a lot of questions in that class (II 2).

Confidence

Maureen had been told by many people that she was “confident and poised”. However, in science and math class “I feel unsure of myself and very unintelligent”. Maureen further elaborated on her feelings of confidence in science.

I can’t express myself in the ways that I want to and I often don’t even try. I know that Mr. Hanes is a good teacher, but the whole atmosphere of the class is intimidating. I know
that he doesn’t mean it, but Mr. Hanes has the tendency to act in a negative way to questions that may not be that well thought out. That is part of what keeps me from asking. Although I don’t remember it ever happening directly to me, when a girl has asked a “stupid question” and has been reprimanded for it, not only does she have to face that, but then the boys of the class chime in with disrespectful comments. It’s hard for me to understand why I don’t just ignore it. When it has happened to me, I just feel so stupid. There is no other way to describe it. After even a small incident, I am extremely hesitant to volunteer again. Even worse situations occur when a teacher is looking for an answer from the students.

In science class, I am often 89% sure of an answer, but I don’t even try. Getting it wrong would be too devastating. I know it shouldn’t be. I know that others say incorrect answers all of the time, but something stops me. I can’t get rid of the feeling that I will be wrong and I will be embarrassed. I hate thinking that. Inside I know I have the correct answer, but then I doubt it to the point that I think I am wrong. I’ve been trying to stop thinking that way. I don’t even really notice it when it is happening, only after. And then it seems like it was another person completely sitting there in that desk (PGIF).

Maureen’s awareness of women’s learning styles and what actually happened in a classroom made her more aware of her personal situation in the classroom. Maureen is not really sure how to bring about personal changes in her involvement in the classroom. She was planning on continuing to take science throughout high school. Although she was interested in science, she did not plan to pursue a career in science.
Past Science Experience

Maureen’s first memory of science took her back to second grade.

We had to make boats out of clay that would hold the most weight when they were floating in water (II 1).

Maureen had always been more interested in the natural parts of science such as animals and biology. Maureen also remembered in third grade raising tadpoles. Maureen indicated that she believed that the experience really got her thinking about “how animals grow up”.

For a while, I just sort of did science. It was something that was just there.

An experience that Maureen had in eighth grade changed her outlook on science and what it meant to her life.

In eighth grade I went on a Lake Erie trip and it really opened my eyes to all of the things that are out there. I just thought that it was a lot of fun and I enjoyed just gathering the samples, looking at the lake water under a microscope and doing bird watching. It was just little things that I thought were very interesting. Seeing animals in their natural habitat is what I enjoyed (II 1).

The hands-on learning that Maureen experienced gave her a love and an excitement for science. She indicated that it had been frustrating to her to have some of the excitement taken out of her classroom. Hands-on learning and making
connections with the real world allowed Maureen to make real-life applications. Since that experience, Maureen had not been able to make these connections.

Authority Figures

To some degree, Maureen indicated that she viewed the teacher as an authority figure. In obtaining information for homework, she would "probably take it home and look at it again". She felt very comfortable asking her mom and dad what they thought something meant. If, after talking to her parents about her question, and she still "couldn't get it", she would go to the academic assistant to try to "have it explained better than Mr. Hanes could explain it". Finally she would go to Mr. Hanes with her question.

When asked about the series of steps that she progressed through in order to solve a problem, Maureen stated that her parents were authority figures that she could trust.

My father's a neuropsychologist and he knows some stuff about science. He also reads a lot, so he just has knowledge of things like that and my mom too. They're helpful if I'm not reading instructions as I probably should be.

I asked Maureen how she knew that what these people were telling her was the truth. Even here, she was struggling with how she learns and why she acts in a certain way.
I guess that it’s just blind faith”. Why am I dependent on these people? I should be able to figure this out on my own (II 2).

On lab work, Maureen was more likely to ask the other members of her group how to find the answer. If Maureen was not sure that the answer she was given was correct, she would probably go to Mr. Hanes to check on the answer. She had enough confidence in herself to “suspect” when an answer might not be correct.

Learning and Learning Science

Learning to Maureen was being in a new situation and being able to go away from the situation and feel like you have taken something away from it. Taking that knowledge that you’ve gained and being able to use it in your everyday life. Relate it to things that you find in your everyday life (FI 1).

In terms of learning science, Maureen needed to be able to freely experience it hands-on whether that is in a lab in school or on field trips where you can see how science is in the real world (FI 1).

Even though she learned best from hands-on experiences, Maureen did indicate that lectures were important. Student interaction and being able to ask questions was also important.

Maureen’s journal entries also reflected the type of environment and activities that allowed her to learn best. Mr. Hanes had asked the class to construct a concept map on
geologic processes. Maureen stated that she found the activity involving concept maps very "difficult to do and utterly pointless". She attributed her feelings on the concept maps to the type of group that she was "stuck" working with.

I spent a good deal of time keeping everyone on task.

She shared with me that she viewed concept maps as "busy work" and did not feel that they helped her in making connections in her learning. After the groups had completed their concept maps, each group was asked to share their maps with their classmates. Maureen did not see any purpose in having to do this.

The computer activity with the CD-ROM on Plate Tectonics proved to be a valuable learning activity for Maureen. These activities were "self-paced" and "interesting" however, she told me that they did not allow her to process the information that was necessary for the test.

Maureen did like group work when she was able to choose the people that she wished to work with. She also liked group work when we have to use information to make choices based on our data. It's like problem solving and it's a good mental exercise (JE).
Videos did not provide Maureen with an appropriate way to learn science. She found herself getting bored with the movies and wanting to "do something". When Mr. Hanes used the interactive videos with the computer, Maureen felt as if she got more out of the presentation. She did feel that the interactive program would have been more beneficial if the students had been allowed to work in smaller groups instead of the whole class, so that she could have progressed at her own pace.

**Good Science Lesson**

A really good science lesson for Maureen would be a situation where we were given a problem that can be found in the real world and having materials that we can use in our own way to solve the problem. Finding a way or coming up with a way to test certain materials or a chemical. I would like to be given a problem and find a way to solve it (FI 1).

Most of the women in the class preferred to know what the correct answer to a problem is. Many women were uncomfortable with knowing that there might be more than one answer. Maureen, however, was very comfortable with that kind of an approach.

I think that science is really about having different solutions to the same problem. I would be okay with having as many possible solutions to the same problem (FI 1).
Bad Science Lesson

A bad science lesson would be one in which there would be "no discussion and where students could not ask questions". Even though Maureen felt this way, she still could not bring herself to ask questions when discussions were generated in her enriched class. Maureen also indicated that she would be more comfortable in a same-gendered classroom.

Good Science Teacher

Maureen described a good science teacher as someone who "wants to learn as much as they want to teach". A good teacher would not act as if this were the 8th time that they had to teach this lesson and that it is boring to them.

Maureen also believed that good science teachers were interested in what they are doing and encourages students to look for new ways to solve problems. Science teachers need to take what we’re learning beyond the classroom, sort of apply it to everyday life (FI 1).

Bad Science Teacher

A bad science teacher would be one who sees students who are just people that are much less intelligent. A teacher who looks at teaching as something that they have to do. They might enjoy science, but they’re not into it as much as they could be. They have their curriculums that they have to follow, but they’re not bringing the science to life. With these kind of science teachers, it would just be words on a page in a book being recited and regurgitated (FI 1).
Louise

History

Louise was in the second year of the enriched integrated science program. Upon my observations of her classroom, I found that Louise was the most quiet out of all of the women observed. She was a very diligent note taker, asked no questions, and did her work without much interaction from her classmates. Even on labs, Louise was very independent and quiet.

Louise’s teacher from last year commented that she was also very quiet in his class.

Louise was very quiet and would rarely even come individually to ask questions. Out of all of his students, Louise was the least likely to ask any questions. Mr. Smith often wondered if Louise was quiet because she was afraid to ask questions or is it because she feels confident with this stuff? If you know it, you don’t need to ask a question (PT 2).

Mr. Smith also commented that out of all of his women that he had last year, “I would rank her as my most intelligent and that might be why she didn’t ask many questions” (PT 2).

Outside of the classroom, Louise also appeared to be very quiet. Every spring the science department offered a field studies trip to the Bahamas. Last spring, Louise elected to participate in this field study. Mr. Smith was
the director of the trip and commented that she was very quiet the whole ten days of the trip. "She had very little interaction among her peers."

In our focus group interview, Louise was the only woman who did not make a single comment throughout the entire interview. After the focus group interview, the participants were asked to fill out a questionnaire to allow them to add comments that they did not share in the group. Louise commented that she didn’t really say anything during the discussion because everything that I thought or felt had already been said (PGIF 1).

The other women in the group appeared to have accepted the quiet nature of Louise.

Confidence

Louise’s quietness in class had not hindered her ability to be very successful in science class. Over the past couple of years in the enriched program, Louise had maintained an A average. She liked science in general and saw herself going on to take chemistry as a junior. Her senior year she was still debating between physics and/or advanced placement biology.

Louise considered herself a very quiet person and that was based primarily on the fact that she was very shy. I asked her if that was why she did not ask questions, because she was shy. She responded,
Usually, if I don’t understand a question, someone else doesn’t understand it either and they usually ask the same question (II 2).

If Louise found that someone did not ask her question, she would approach Mr. Hanes individually with that question rather than in front of the class. Louise found that Mr. Hanes was able to explain questions to her in a way that she was able to understand them.

**Past Science Experience**

Louise remembered that all of her science classrooms were real bright and decorative and they had all of the lab equipment in them (II 1). The thing that I like about science is the more useful things to me. We’re doing a lab about rocks now and I don’t think that I’m ever going to go out and identify rocks and minerals or anything. I like the more practical day to day science type things (II 1).

Louise’s first memory of science was from seventh or eighth grade. Before that time, she did not remember much about science. During seventh or eighth grade she remembered doing a paper towel lab because I thought that it was pointless because of testing paper towels (II 1).

**Authority Figures**

In terms of authority figures, Louise tended to look toward her dad and the academic assistant. If she was having trouble with a homework question, she would ask her
dad first. If she still did not understand, she would go and see the science academic assistant. Louise went to her father first because "he is smart in everything". Louise also felt that her dad was able to explain things in such a way that she was able to understand it. She also felt very comfortable approaching her dad with any type of question. 

In terms of lab work, if Louise and her group were stuck on a question or procedure, they would ask Mr. Hanes. Louise commented that she would not be the one going to Mr. Hanes with the question but rather another group member. Louise indicated that she believed that if another lab group gave them an answer that she did not feel was correct, she would "argue about it." However, Louise said that she wasn’t sure how she knew when something was the right answer.

Learning and Learning Science

Louise defined learning as

increasing your knowledge about something. It doesn’t have to be school related, but about anything in everyday life (FI 1).

When asked how she learned science, Louise commented that

it’s easiest to learn with hands-on activities and by being given examples (FI 1).

Louise believed that the hands-on activities make learning easier because
you can apply what you’re learning and can test it out. It just makes it easier to figure things out in your mind, practicing them (FI 1).

Louise believed that class discussions were beneficial; however, she

prefers just to listen and believes herself to be a very quiet learner.

Louise did not find lectures beneficial because she

doesn’t know exactly what we have to or are expected to learn. I get kind of bored and tune everything out. It’s easier for my mind to wander during lectures (FI 2).

In Louise’s journal, she reflected on other ways of knowing science. Louise struggled writing creative essays for science because she had “never been the creative writing type” (JE). She was much more comfortable writing research essays instead.

Louise did not like group work because she felt that she usually got stuck doing most of the work for the project. She related to a concept mapping project where she immediately took charge and the guys in the group didn’t seem to mind (JE).

Louise commented that she did most of the concept map at home on her own time.

I guess my strong sense of responsibility gets me left doing group projects by myself or something like that (JE).

The next day, Mr. Hanes commented to her whole group on how well the concept map was done.
I felt that I should have been the one being complimented because I took 30 minutes of my own time last night to finish the map (JE). I always feel that if I don't do the project, it will end up being wrong or not very well done. I guess I've always followed the motto, 'If you want something done right, you've got to do it yourself' (JE).

Louise did like the computer programs that allowed interaction. She believed that they show exactly how things work and explain what is happening.

She also liked how the continental drift program had a "review section after each chapter". The information that Louise gained from the computer program allowed her to score a 75 out of 77 on the test the next day. This was the highest grade in the class and she was quite proud of her accomplishment.

Louise indicated that movies had some value in class if they were not used everyday. She felt that all they had been doing was watching movies and she was finding herself bored and is letting her mind wander during the movies (JE).

Louise had a real problem staying focused on whatever they were learning at the time if she could not see the relevance of the topic to her everyday life.

Good Science Lesson

Describing a good science lesson, Louise indicated that this involved lab work or hands-on activities.
I think that you learn a lot from doing labs, especially when he explains how to do everything and then research it (FI 1).

I asked Louise if she would be comfortable if she came up with two or three really good answers to a lab problem.

I get kind of worried when there is more than one correct answer. I feel more comfortable knowing that there is one set answer (FI 1).

**Bad Science Lesson**

A bad science lesson would be one in which the class period was spent watching a movie or being lectured to.

It’s too easy to get bored and then to allow your mind to wander. Most of the time, they are pointless (FI 2).

**Good Science Teacher**

A good science teacher for Louise would be someone who would

try different things and help different types of learners take in all of the information (FI 2).

This type of teacher would also

try different activities and use different methods to get their point across (FI 2).

**Bad Science Teacher**

A bad science teacher was someone who sticks to just one teaching method. One teaching method doesn’t work for everybody, they need to have some variation (FI 2).

A bad science teacher would make it uncomfortable for students to approach them with questions and ignore students that don’t understand something (FI 2).
History

Liz also presented herself in science class to be very quiet in class discussions and asking questions. However, in lab activities, Liz was very interactive and social in asking questions and solving problems. In her first year of enriched science, Mr. Smith defined Liz as "very quiet and spent the year working with Marie. Even though Marie was the spokesperson for the group, Liz would definitely come up and ask questions" (PT 1). Most of the times, Liz would ask questions individually and not in front of the class during her first year of enriched science.

Liz admitted that she was fairly quiet in class.

I'm really shy. When I'm with my friends, I'm not quiet at all, but in class, I'm just really quiet. I feel confident that if I had to ask a question that I would (II 2).

In her second year of enriched science, Liz would ask her question in class rather than try to ask Mr. Hanes individually.

I asked Liz about one of the class presentations that Mr. Hanes had given over rocks. I wondered if there were times when she had questions or things that were presented that she had not understood and wanted to ask a question.

Sometimes when we're doing notes and stuff, he goes over things really quickly and I just kind of lose it. I don't get caught up but I won't interrupt him and ask him to repeat stuff.
I’ll just get the information from someone else, if they followed it” (II 2). I wouldn’t feel comfortable telling him to slow down.

Liz did care what Mr. Hanes thought of her and had a tendency to believe that was why she did not ask questions. The fact that her class was mostly males did not intimidate her from asking questions. However, Liz did believe that if she was in a class of all women she would probably have felt more comfortable asking questions. Liz also needed processing time to think about a question before she gave an answer. The males that dominated the classroom do not give her the time necessary to do that.

Confidence

I was surprised to find out that Liz’s worst subject was science. She shared with me that she just did not have a scientific mind.

I’m good at math. Math is my best subject and I suppose that they sort of go together, but it’s not that way (II 1).

I was curious about what made Liz believe that she did not have a scientific mind. She responded,

I don’t know. It’s just my own conclusion. I guess that I’m good at science, but out of all of my classes, science is my worst one. I’m probably good at science, but not as good as everything else, so science is my weakest subject (II 1).
Even though Liz viewed science as her worst subject, she was still getting an A in the enriched section of science. Liz commented that even though I have an A, I’ve worked very hard for that A. It hasn’t come easy for me, I’ve really had to work.

Liz also received an A in the enriched section of the year one program, but felt that this year was much harder. Liz did not believe that Mr. Smith was easy, but easier than Mr. Hanes. It’s still really fun, and I learned a lot more than I did last year, but I have to work harder (II 1). The quizzes were easier last year and Mr. Smith explains things better than Mr. Hanes.

Liz also remembered that the students did not have to do as many papers in the year one program. The lab reports in year two were expected to be a lot more detailed than last year.

Liz felt that her best subject overall is Spanish. In terms of science for her junior year, Liz was planning on taking chemistry, and then physics in her senior year. Liz liked chemistry over any of the other disciplines of science, followed by biology, physics and earth science.

Past Science Experience

Liz’s first memory of science was chemistry in the fourth grade. That was really neat. I love chemistry. I remember we tested rocks with the acids and then mixed chemicals and did stuff with salt and sugar (II 1).
Liz did not have as many pleasant memories from her middle school experience because they did not do much chemistry. Also they had a first-year teacher, and spent most of the time on earth science.

Our teacher was just getting used to how to teach. All of my science classes, I mean, they don’t make me feel uncomfortable in them. If I don’t know how to do it, I’ll just ask someone. They don’t make me feel stupid or anything like that (II 1).

Authority Figures

In terms of authority figures, Liz felt fairly comfortable with herself in knowing whether or not something was relevant or not. If she had questions on a homework assignment, Liz would call her friends because they would probably understand it. It’s easier to do that because then you can suggest things to each other and then see what works out best (II 2). There’s not really a fear of a wrong answer if you’re just chatting.

If Liz was working on a lab and had trouble with a question, her lab group would probably go to Mr. Hanes for the answer. Liz commented that she would probably not be the person going to Mr. Hanes with the question, rather, someone else from her group. Liz stated that she believed that Mr. Hanes knew the answer because he is more experienced and knows more than I do, so I’ll just take his report (II 2).
Liz also felt comfortable approaching Mr. Hanes to ask for help in finding information for research projects.

In doing lab work, if Liz felt that one of her group members came up with a wrong or incorrect answer, she would ask the group member to explain her answer.

I wouldn’t come right out and say that she was wrong. But, I wouldn’t feel bad asking her if she was sure it was the right answer (II 2).

Liz was very comfortable in knowing that there might be several possible answers as a solution.

**Learning and Learning Science**

Liz defined learning as experiencing new things and gaining knowledge about them (FI 1).

In learning science, Liz learned best by doing experiments and observing how things work such as doing labs (FI 1).

Liz’s journal reflected that she did not like student presentations because you don’t really learn anything except for the section that you did (JE).

She did like learning by completing concept maps because it helped her to “tie together” the concepts that she had learned. The computer programs that were interactive helped her to learn and tie together concepts as well.
Liz’s comments concerning the movies that they had watched in class were fairly positive. She liked the video with the worksheet because it helped to make the video more interesting.

The guideline questions cause us to pay more attention and get more out of the video.

Even a lecture on earthquakes was interesting to Liz. She did not find the lecture boring like most of the lectures.

The lab on fast plants really interested Liz.

I think that I’ll like doing this because we’ll get to see how cross-breeding and all that works instead of just reading about it (JE).

Liz said that when you actually do something, like an activity, you remember it more than if you just sit there and listen about it.

Good Science Lesson

For Liz, a good science lesson would be one where the topic was discussed and how it works and then we actually go out and observe it and experience it first hand. That would be a good way to learn (FI 1).

Bad Science Lesson

A bad science lesson would be one that was “just a lecture about something”. Lectures did not allow Liz to do the type of learning that she would like.

Lectures get boring and you just tune it out. You don’t learn as much (FI 1).
Good Science Teacher

A good science teacher would be “creative and always finding new ways to teach stuff”. A good science teacher would also be

helpful, really informative, and will help you or will lead you to the conclusion.

Liz believed that good science teachers will think of new ways to teach instead of just “reading it out of a book” (FI 1).

Bad Science Teacher

A bad science teacher would be one that

wouldn’t help you if you didn’t understand something (FI 1). The teacher won’t help you, they’ll just tell you to re-read the instructions or something.

Marie

History

Marie was in the second year of the enriched science program. Upon my observations of the class, Marie was not as quiet as some of the other members of the class. She appeared to be fairly comfortable with asking questions from Mr. Hanes, mostly on an individual basis. Mr. Smith commented that last year, Marie was usually the spokesperson for her group and had no problem approaching him with questions.
When I asked Marie about the quietness of the women in her science class, she did not feel that she was shy in her science class or any of her other classes.

I'm used to basically everybody around me and I'm not going to try to answer something that I don't understand because I don't want to answer it totally wrong. I'm not afraid to ask questions or anything like that. If I know the answer to a question, I'll answer it. I'll always raise my hand to ask questions, but I won't sometimes to answer questions unless I'm sure that I'm right because I don't want to do that. If it's a bad day for me or if I'm just being lazy that day, I'll be half there and I know that they'll take the questions if I don't feel like answering them (II 2).

Marie commented that the women in her class are "outgoing" even if they did not appear to be. The males in the class just seem to jump at the questions quicker. It's like on some days we want to be sure that what we say is pertinent (PGIF).

Confidence

Marie was fairly confident when it comes to her science ability.

I've been fairly good in school. I was fairly good in elementary school at most things so I was okay at science. It used to take me a while to get things done sometimes cause sometimes I would have to work a little bit slower so I made sure that I had everything (II 1).

Last year in Marie's year one enriched class, there was a lot more time spent on computers and computer activities.
We used more of the new technology. I remember that last year I had to come in for more extra time. Maybe it was because it was my first year in enriched, but for whatever reason, I couldn’t get my work done in class last year.

I asked Marie what made her decide to continue on this year with the enriched track.

I took it because I took it last year, and I figured that if I did it last year I could do it this year. I got into enriched last year because I had done pretty good in 8th grade, so I figured that I should try the enriched (II 1).

Marie had heard from other people at the high school that the enriched track was not all that much more difficult than the regular track.

Past Science Experience

Marie’s earliest memory that she had of science was in the fourth grade when they did identification of something like rocks and minerals.

I think that it was powders or something because that’s like the first time we started to use reactors and things with body systems (II 1).

Marie also remembered going to her grandmother’s farm a lot when she was younger and “seeing nature”.

Marie remembered when she was between three and five years old, having a garden and helping her mother. She knows that it was not a “big science experience”, but it piqued her interest. Marie was not crazy about bugs and did not have good experiences with some insects as a youngster.
Authority Figures

If Marie was given a homework assignment that she did not understand she would "probably call someone in the class who she knew". Marie would do this because if she was at home, she was able to find the answers before the next day and allowed her to "understand it better". Marie also found that her friends were able to explain the answers "pretty easily". If Marie's friend was unable to provide her with the answer, she would try to find the teacher during a free period or study hall to ask her question. Marie felt comfortable asking Mr. Hanes questions and approaching him with questions.

In terms of lab work, Marie and her group would ask Mr. Hanes for the answer. They believed that Mr. Hanes understands the whole thing and would be able to provide them with the correct answer (II 2). If Mr. Hanes was not available, the group would probably refer to another group for the answer. Marie stated that she would not necessarily take the other group's response as being correct.

Learning and Learning Science

Marie defined learning as

gaining new knowledge on something that you didn’t know before hand or improving on something that you already knew about (FI 1).
Marie learns science best by actual hands-on experiences such as experiments, labs and demonstrations and stuff like that" (FI 1).

This type of a learning situation made it easier for Marie to learn science because you could more or less see it happening or see how it works, more of a visual thing than just being told about it. It’s easier to understand that way (FI 1).

Marie gave several examples of hands-on activities that she had enjoyed this year. She liked the lab with rocks and being able to "do all of the testing things." Marie did not like lecturing because she wanted to "be more involved with her learning." She also commented in her journal about her fast plants lab where she was actually able to see and watch the plants grow from a film canister in a liter bottle.

As far as videos were concerned, Marie’s journal reflected mixed feelings. The video on fossils was very "boring" to her, while the video *The Earth Has a History* was very interesting to her. For the second video, she had to fill out a handout with answers which meant that "she had to pay attention."

Marie liked group work, especially when it came to lab work. Group work allowed us to get our work done quicker and were a lot more fun than working individually.
Marie also expressed concern in making her work "look good" as compared to just "getting it done." Visual models of geologic time periods helped Marie to "understand it better than just reading about it."

**Good Science Lesson**

A good science lesson for Marie was a science lesson with

- a lot of variety with some notes that are already written out for you so you can get that.

This would be followed by some "demonstrations and maybe a short video". Marie was a firm believer that a science lesson should cover

- all the ways that most people learn because that would be the most likely way of having everyone take something from the class.

In a science lesson, Marie liked to see a "little bit of everything" because

I don’t necessarily always learn one way. Some things get across to me better through a lecture and some things make more sense if I see it and some things make more sense if there’s a really good video. Each way looks at it differently and I get it through one of those ways (FI 1).

**Bad Science Lesson**

A bad science lesson for Marie would be one that spends too much time on a particular learning strategy. Marie felt that lecturing the whole time, which "goes in one ear and out the other, if you get too much", was not beneficial.
Also, a “really boring video that lasts the whole period”, would be a bad science lesson. Marie defined boring as “one of the older videos that had the narrator with the monotone voice” (FI 1).

**Good Science Teacher**

A good science teacher should “have a lot of background in the outside science world”. This would allow the teacher to have been “through all of that and they can cover everything for you”. A good science teacher would also be able to “answer your questions on anything that you ask”.

**Bad Science Teacher**

Marie described a bad science teacher as one who “won’t answer any of your questions”. This type of teacher goes way too fast and they only have one teaching style. This one style is the only thing that they’ll do and they won’t try anything new (FI 1).

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**Melissa**

**History**

Melissa was the most outgoing and vocal woman in the study. She did not hesitate to ask questions or participate in discussions, provided she was interested in the subject
matter. On several occasions, I observed Melissa offering her opinions and asking questions on volcanoes and plate tectonics.

Mr. Smith shared with me that Melissa was everybody's friend. She is very outgoing, and very enthusiastic about everything. She would ask questions all of the time and she would come up and tell me if she didn't get a suitable answer. There were times when Melissa and I would buck horns a little, but we worked it out and now she comes by and shows me her drivers license and tells me how things are going. She has a lot going for her (PT 2).

Melissa shared with me that her enriched class last year did not have as many males in it as this year's class has.

Last year was a little more balanced, but it seems like the guys take the more dominant role, especially this year. The guys were a little more dominant in the classroom than what we were. You would try and everything, but it seemed that they knew a little more (II 1).

Melissa confirmed my observations by sharing with me that she did not feel intimidated in asking questions.

If I feel like I have a question, I'll ask. Sometimes in the case of I don't understand, or if he's already explained it a couple of times, I might feel embarrassed and ask him later (II 2).

Confidence

Melissa was in the enriched section of science last year and enjoyed it more than she had this year. Last year
during her enriched science, a lot of time was devoted to earth science. That was Melissa’s primary interest. The first half of this year had been spent doing molecular science and cell structure and I don’t like that. Any kind of medical science, I don’t like that.

Melissa was not happy with her performance this first semester of her sophomore year.

I got a 2.9, I was really upset, I don’t know what happened. Last year I had a 3.2, in middle school I had a 3.4 or 3.5. High school was kind of a shock and I realized that I needed to study a little harder.

As the year progressed, Melissa had turned assignments in on time. “I told Mr. Hanes that I’m turning over a new leaf”. Melissa was noticing improvements lately. Her last lab report she received a 60 out of 65.

Melissa believed that she had always been fairly good in science but she attributed her success to her parents, rather than anything that she had accomplished.

My dad is an electrician and he’s been through Catholic school and my mom majored in Chemistry for the first three and a half years of college. Both of my parents are really scientific (II 2).

In terms of Melissa’s less-than-perfect grades, Melissa’s mom told her that she was just not trying hard enough. After making more of an effort, Melissa felt a lot better about her improvements in her science course. It was originally Melissa’s mom who strongly suggested that Melissa
take the enriched course. Melissa did not want to take the enriched course because she did not want to go into the medical field and she heard that Mr. Hanes was a hard teacher. Melissa was planning on taking regular chemistry for her junior year.

**Past Science Experience**

Melissa really enjoyed her last year in science with Mr. Smith because the focus was on earth science.

Eighth grade was okay, it was nice and I found seventh grade to be a little more challenging because of the teacher. In elementary school, I loved science. (II 1).

Melissa described her experience in her last year’s enriched class as very memorable because of Mr. Smith.

Last year my teacher, he expected a lot out of us, like my teacher this year does, but I think that his expectations were different. I think that the reasons why were that he is not quite set in his ways. He’s a younger teacher and I think that he was open to newer things. He was still trying to test things out. He didn’t have that problem, ‘Well, I’ve done this project every year for the last ten years, it’s like this’. He was always open to change. This year my teacher is open to change, but he’s a little more set in his ways, he does what he likes to (II 1).

Melissa’s other memories of science involved a battery and bulb unit that she did in sixth grade. In fifth grade science, Melissa’s teacher brought in “cows hearts and lungs and actually put the air pump through the bronchioles” (II
1). Both of these experiences provided Melissa with very memorable experiences in her early years of science.

**Authority Figures**

Melissa felt that Mr. Hanes was very approachable and that "he doesn't get approached enough". When Melissa was having trouble with a homework question, she tended to go to her mother first because "she knows science really well". Melissa would not go as far to say that her mother was an expert in science, but that she "knows it really well".

In doing lab work and assignments, Melissa was more likely to go and ask somebody else in the class. If they were too busy to answer our questions, Melissa and her group would go to Mr. Hanes. In obtaining information from other members in her class, Melissa was still careful in checking out the answer with other class members or Mr. Hanes if she was not sure of the answer. Melissa was comfortable knowing that there might be more than one right answer.

Melissa felt that Mr. Hanes did a good job of explaining information in a way that she could understand it.

At first, I didn't understand him and the way that he functions. But now that I do, he explains everything just fine.

If Melissa did not understand something that Mr. Hanes had just explained, she would usually ask him to explain it again.
Melissa also thought that Mr. Hanes played a very large role in determining where she went to get her information. "Usually he tells us without us even asking" (II 2). Melissa usually had some ideas as to where to go for information before Mr. Hanes shared his ideas with her.

Learning and Learning Science

Melissa believed that learning did not mean always getting an A. I think that learning is getting something out of the lesson or whatever the lecture is that day.

Melissa felt that you should be able to walk away and tell someone a little bit about what we did. Not just for that day, but I could remember it for some time (FI 1).

Melissa indicated that she learns science best by working on computers and interactive programs. Melissa was able to get a pretty high score on the test because she did a "hands-on activity". Student presentations for Melissa also presented another avenue that she learns effectively from.

You have to know a lot about your topic in order to get up there and present (FI 1).

Melissa indicated that lectures were not an effective way for her to learn. She did not like lectures because they are boring. I like to talk to people, I don’t like somebody to just talk to me and say this is how it is (FI 1).
Good Science Lesson

A good science lesson for Melissa was one in which it was primarily hands-on. She gave an example of doing a "lab with maybe five to ten minutes of just explaining" and then going "back and actually doing the lab to actually understand it". Closure was very important to Melissa because if there was no closure, there is "no way to link one concept with the next" (FI 2).

For the most part, Melissa was able to see connections in her current science class. Especially in the area of the earth sciences.

We did the theory of plate tectonics and now we're talking about earthquakes. It's almost like building blocks. If you don't know the theory of plate tectonics, continental drift, stuff like that, you're not going to really understand earthquakes and faults and stuff (FI 2).

Bad Science Lesson

A bad science lesson would be described as one in which Melissa did not get anything out of it. When he is starting to lecture, I doze off, or I might quietly do some other homework and make it look as if I’m writing notes. If I’m taking notes, I might find myself doodling. That’s how I know that it hasn’t been a good lesson (FI 2).

Good Science Teacher

A good science teacher would be someone who "does a combination of everything". Melissa said that she believed
that you just could not “stick to one person’s needs”. For instance,

you can’t always lecture because that makes for a boring class. However, some people really like lecturing (FI 2).

Melissa said that she believed that a good science teacher would do a lot of lab work and hands-on activities.

**Bad Science Teacher**

A bad science teacher was someone who just “uses one method to get his point across” (FI 2). For Melissa, this would be strictly lecturing. She also talked about some science teachers that were

not open minded enough to accept that some of the things in science are still theory. Science is always changing, one thing that might be true one day is proven false the next day (FI 2).

**Focus Group Interview**

**Impact of Study**

The focus group interview gave the women of the study a chance to examine some issues further and to get a chance to see how the other women in their class felt about the topics of the research study. I was very interested in knowing if, by participating in the study, the women became more aware of how they behaved or learned in a science classroom. All of the women in the study agreed that they had become more aware of their learning in their science classroom. Nicole
became "more aware of her body language during certain activities" (FGI). Lauren wanted "to get every little thing right on labs".

Overall, most of the women realized that they were not active participants in the classroom, but were not sure as to the reasons why. Maureen stated that the study had helped her to look more at the way that she behaves in science class. I think that this will help me in the future to evaluate how I am learning and how I learn most effectively (PGIF).

Group Work

The women did not all share the same feelings concerning group work. Liz did not like group work because you're stuck working with people that don't want to work. In elementary school, they would stick smart people with dumb kids and the smart kids would end up doing all of the work (FGI 2).

Maureen commented that it's not that the people are not capable of doing the work, it's that no one trusts them (FGI 2).

Lauren agreed that group work was usually not beneficial to her and "would rather work by herself". If Lauren did have to participate in group work, she placed herself in a group where people are not going to be dependent on me. I'm with people that are more willing to work (FGI 2).
Most of the group agreed that if group work was going to be effective in the science classroom, the students should be able to self-select themselves into those groups.

Thinking for Themselves

The women in this study did not judge that their current science class encouraged or allowed them to “think for themselves”. Lauren stated that it was easier for her to think for herself when she wasn’t actually in the class. If I’m reading the information by myself or if I’m doing homework at home, I sit there and think about it. If I’m in class, and I have to take notes and fill something out as I go, then I don’t think (FGI 3).

The women also stated that many times they were rushed to complete an assignment or activity, and that this did not allow them to process the information.

Nicole: I don’t remember anything on the computer.

Liz: Probably because we were so rushed to get that done.

Maureen: There was so much information and we only had two days.

Liz: The guys in our class, they just skip through it, they don’t try to process the information.

Recommendations

The women in this study were asked to make recommendations on ways to change science, or make a science classroom more female-friendly.
Lauren: Make it more like field studies.

Liz: Very little lecture.

Lauren: Labs to reinforce the lectures, but no formal lab reports.

Maureen: I would advise younger girls to be more confident in class.

Liz: Don’t be intimidated by guys and ask your questions. I think if the males and females were in separate classes, especially science and math, the females would learn a lot and not be as intimidated to ask questions.

Claire: I think that it’s good the way the enriched classes have a small number of students because I’ve found that in a lab situation, if there is more people, it’s confusing and there’s not enough time.

Lauren: I think that all females need to be more assertive and take the initiative. Go out on a limb sometimes and be risky, both at work and play.”

Problem Solving

All of the women of this study were asked to participate in a constructivist lab in three small women groups to examine problem-solving strategies. These labs took place over the women’s lunch hour and were audio as well as video taped. In two of the three groups, one of the women took charge of reading the instructions and telling the group what needed to be done and how. Lauren assumed this responsibility in group one (Lauren & Katie), while Maureen assumed this responsibility in group two (Maureen,
Louise and Claire). Group three (Liz, Melissa, Nicole and Marie) did not have a dominant individual, rather they took turns reading and actually doing the procedures.

Groups one and two, for the most part relied on the answers that the dominant individuals suggested and seemed to be content that they had the right answer. There was not much discussion in these groups. Group three had much discussion in terms of calculations; set up procedures, and also demonstrated questioning of other group members’ answers. Group three demonstrated an example of collaborative group work. All of the groups commented that they did not have any problems following the instructions or coming up with answers.

Additional Evidence

Outside Help

Mr. Hanes was asked to comment on how he viewed the women of his class in terms of asking for help on questions outside of class.

Females do not seem to come for help outside of class. This is not unique to just females; very few enriched students seek outside assistance. The vast majority of the students are earning good grades (A’s and B’s), so most students don’t feel a need for outside help. Most of the students seeking outside help are in the low B grade range, and a lot of the questions seem to be associated with not having homework completed on time. Most of the questions reflect student unwillingness or inability to put the time in to do the work in a high-quality manner (CT).
Class Participation

Mr. Hanes was also asked to comment on the class participation of the women in his class. I was interested to see if he called on the women in his class when their hands have not been raised.

I have tried to call on others in the class. This has been difficult, as the boisterous males I have referred to take that as yet another opportunity to insert themselves into the class discussion and monopolize things. I have called on females who haven't raised their hands from time to time and the reaction seems to one of great surprise. The females in class, for the most part are good students. They earn good grades (A’s and B’s) and, when called upon in these situations, generally know the answers (CT).

Work Ethic

Mr. Hanes commented that the women in his class usually do an excellent job of handling lab work and writing up lab reports.

One of the women in his class turns in work that is the best that he has seen in all his years in the classroom, detailed and insightful. I consider most of the work that I receive from females in the class to be above average and of high quality (CT).

Mr. Hanes ranked the women’s work ethic as being very high and saw this in direct relationship to them wanting to earn good grades. This desire was reflected in questions
such as "What do I need to do in order to earn an A"? as opposed to questions like "This is interesting. Where can I go to learn more?"

In reflecting on his eighth period class and considering how women learn science best, Mr. Hanes understood why some schools are putting women into classes that are separated by gender. Mr. Hanes felt that by doing this, it might be one way to keep adolescent females from being intimidated and overwhelmed by adolescent males who feel a need to dominate class proceedings (CT).

Ways of Knowing Science

The nine women in this study did not fit neatly into any of the five categories described by Belenky et al. (1997), but moved across several ways of knowing science depending on the situation. The ways that these women learned science was a very complex and difficult process. The women in the study had been able to be successful in science despite being in a male-dominated classroom.

As I examined the data, themes emerged that helped to describe how these women learned science. These emerging themes from different sources were compared with each other. For instance, my observations showed that the majority of the women in the class were very quiet and did not participate in classroom discussions. I reviewed
transcripts of interviews, student journals, focus group interviews and lab activities to test the viability of this theme, as well as to look for disconfirming and confirming evidence for each of the nine women in the study.

The multiple data sources that I used in the study helped me to triangulate the emerging themes. The purpose of triangulation was to link the multiple data sources for making a better interpretation of the data. Triangulation also helped in enhancing an understanding of the various events that took place during the study (Bogdan & Biklen, 1992).

The classroom provided an environment that supported a variety of ways of knowing. At times, the classroom was strictly a received knowers classroom, while at other times, the classroom provided opportunities for a constructed way of knowing. Even though the classroom provided for a variety of ways of knowing, most of the women in the classroom did not take advantage of this. This might be due in part to past science experience, perceptions of school science, and perceptions of teaching by the women in the study.

Some of the women in the study quieted their subjective ways of knowing science due to the fact that there were fewer women in this class than in their previous science
classes. In other words, in another situation, these women would have felt comfortable participating in discussions and asking questions. Most of the women in the class avoided any confrontations with the males in the class, and tended to become received knowers when it came to class discussions.

Some of the women demonstrated a silent type of knowing behavior in the classroom. Belenky et al. (1997) shared a concern for this silencing behavior that took place in this classroom. The silencing behavior that the women demonstrated actually decreased their chances for any further connection with their learning. The silence in the classroom encouraged the women to become isolated, and kept them from being able to develop a connected procedural perspective or a constructed knowing perspective.

The following descriptions were an attempt at describing the women of the study and the ways that they came to know science. The quest for self and voice played a strong determinant in the transformations of these woman’s ways of knowing.

Katie

Katie’s ways of knowing science had moved across several different categories through her science
experiences. During the past year, in her enriched science class, Katie had been a received knower. Katie indicated that she believed that her classmates and teacher were authority figures and could provide her with appropriate answers to questions. Katie was a good listener and was able to remember and reproduce the knowledge that she had learned. It made Katie uncomfortable to know that there might be more than one right answer for a question.

In her enriched class, Katie had little confidence in her own ability to speak and was open to take in what others had to offer. Watching Katie perform on labs confirmed the fact that she believed that the truth came from others. Katie also found comfort in knowing that there was one right way to do things and one right answer to every question. Even though Katie indicated that Mr. Hanes was not always approachable or able to explain answers to her in a way that she could understand, she still viewed Mr. Hanes as an authority figure. Katie equated her learning in terms of receiving, retaining and returning the words of Mr. Hanes.

Katie became very frustrated in her enriched science class and came to realize that she could not approach Mr. Hanes with questions or problems. In her opinion, she was experiencing a failed male authority and was seeking authorities who were more like herself. Her realization of
the internal struggle allowed her to take control of the situation and she requested a transfer into the regular classroom.

Katie indicated that she recognized that this type of knowing in her enriched class made her uncomfortable and did not feel as confident or successful as she had. After Katie switched into a regular integrated science classroom, she was able to re-establish the connections that she had experienced during her 8th grade year. During the time in Mrs. Jones' classroom, she was able to move more into a connected procedural knower.

While in Mrs. Jones' classroom Katie was able to make connections with the materials that she was learning as well as personally experiencing the knowledge. In her lab groups, Katie felt more like an equal with her group members and did not feel as if other people were superior to her. Also, this classroom had a more equal number of males and females and the males did not dominate the classroom discussions. Katie stated that she felt more at ease in her new learning situation and even found herself participating in classroom discussions again. The slower pace in the regular classroom gave Katie an opportunity to process the information and ask pertinent questions over the materials.
Katie's inner voice cautioned her to be careful as to what she was thinking; and therefore, she was cautious in sharing her ideas. Many times Katie felt that her ideas or answers might not be correct, and therefore silenced her. Katie needed time to think before she spoke and felt that her comments should measure up to certain objective standards. These ways of knowing demonstrate a procedural way of knowing science.

However, in order to be fully procedural, according to Belenky et al. (1997), Katie must be able to demonstrate both separate and connected procedural knowing. All of the evidence that Katie had shown did not lead to that conclusion. Separate knowers argued their point and made themselves vulnerable to criticism which Katie had not demonstrated. She had not demonstrated a desire to remove herself from the content that she was learning. The experiences that Katie had shared were all of a connected procedural knower.

Lauren

Lauren was the closest to a constructed knower than any of the other women in the group. She constantly strived to make connections with her learning and to integrate the knowledge that she was being presented. Lauren also had
abandoned the either/or type of thinking and was very comfortable with the fact that there might be more than one correct answer to each problem.

Lauren was very comfortable asking questions in class and was not the least bit intimidated by the dominate males in the class. She indicated that she believed that knowledge was constructed and that she was a valuable part of her learning experience. Instead of backing down to contradiction and conflict, Lauren was challenged by these because it allowed her to see the connections in her learning. Lauren was able to tie together the pockets of information that helped her to learn.

In all of my observations of Lauren, she demonstrated what Belenky et al. (1997) termed “really talking”. Lauren listened very carefully and was ready to question, argue, speculate or share information with others. This was Lauren’s way of connecting to others and the knowledge that she was experiencing.

Lauren realized that by being in the enriched class, she was not having her needs met and was not able to make connections in her learning. By transferring to Mrs. Jones’ class, she was able to enjoy learning because of the hands-on experiences and personal connections that she could make with her learning.
At times during the study, Lauren also demonstrated evidence of the connected procedural knower. Lauren believed that the most trustworthy knowledge came from personal experience rather than authorities. She had also developed procedures for gaining access to other people’s knowledge through questioning and arguing. This allowed her to internalize the information and knowledge that she was exposed to.

Lauren did not particularly like group work, unless she was able to choose the group that she wanted to work with. In these groups, Lauren was able to connect with her other group members and collaborate to solve problems and resolve issues. The groups provided a way that Lauren could understand other people’s ideas in other people’s terms rather than her own terms.

Lauren did not demonstrate any evidence of being a separate procedural knower however. Lauren did feel a personal involvement in the pursuit of her knowledge and had great confidence in herself that her answers were correct. She also demonstrated her ability to question authority figures when she had unresolved issues about what was being taught. Lauren wanted to know what people thought and why they thought what they did.
Lauren was a very strong leader in her class and presented herself as very confident in her learning of science. Her dropping into the regular science class was not an indicator of her lack of success, but rather her ability to take charge of her learning situation. She indicated that many times in her enriched classroom she was being forced into the role of a received knower and this conflicted with her ways of knowing. Lauren wanted to take her learning into her own hands and moved into a classroom where she was once again able to make connections with the knowledge.

There were many reasons why Katie and Lauren were once again successful after entering the regular science classroom. Their success could be attributed to factors such as: an easier curriculum, easier teacher, type of classroom environment, type of teaching methods, or nature of the textbook. All or some of these factors played an important part in the success of the new class.

Nicole

Nicole had always enjoyed science for as long as she could remember. She loved science and it came easy for her. During her middle school years, Nicole had many positive experiences that gave her confidence to excel in science. During her freshman year, Nicole realized that she needed to
understand science at a deeper level and chose to enroll in the enriched section of science. She had developed a new confidence in herself and her ability to know science.

Nicole also moved through several stages of ways of knowing in her high school experiences. In her regular class during her freshman year, Nicole displayed herself to be a connected procedural knower. She firmly believed that her most trustworthy information came from personal experience and hands-on activities. She was very effective at group work and took charge on many of the projects. Nicole quickly volunteered to participate in class and shared her comments on certain topics without much prompting.

During the first year, Nicole also provided evidence for subjective knowing. Nicole would listen to what her “gut” was telling her in terms of knowing what was right or wrong. She still believed that there were right answers to the problems that she encountered in science, but that she might be the source of finding these “right” answers.

A subjective knower believed that first-hand experience was a valuable source of knowledge and they had not yet realized the power of their own minds. As Nicole’s first year of high school science progressed, she realized the power of her own mind and had redefined the nature of
authority from external to internal. It was at this point that Nicole realized that the enriched course might have challenged her more and allowed her to know science in a more meaningful way.

Once in the enriched section of science, Nicole found herself falling into a received knower of science. She did not participate in class or volunteer answers in discussions. She demonstrated the behavior of the silent learner, but still continued to think for herself. Nicole found herself listening to the voices of others and found that she now did not have the confidence to speak her mind in the enriched class. She allowed her teacher to determine what she was supposed to learn and did not question his authority. During the experience, she was not able to make the connections in class with reality. The lack of making connections made science very frustrating for her and she found herself “failing” at something that she had loved so much. Her current classroom environment did not allow for Nicole to develop her connected procedural perspective.

Nicole lost her confidence in herself to ask questions and to speak her mind in her enriched class. She did not feel “as smart” as the other kids in the class because they had taken the enriched class the year before. Nicole became a received knower in her enriched class and became more
reliant on the teacher as her source of knowledge. Internally, Nicole still questioned some of the information and material that was being presented in the class, but she did not voice her concerns.

Claire

Claire’s early experience in science left her with very few pleasant memories. In middle school, most of her science had very little hands-on activities. Claire had always been good in science, even though it was not one of her favorite subjects. Her early classroom environments were ones that encouraged a received knower perspective. These early experiences shaped how Claire was able to learn science and become successful without really making connections with the materials. For the most part, Claire continued in her high school experiences to remain as a received knower.

Claire was silent in her enriched science class and allowed the teacher to decide what she was supposed to learn and what was important to her. Claire only found herself questioning the teacher if she was sure that something was wrong. This demonstrated a subjectivist perspective. She did not ask questions because she believed that there were no questions to ask.
Claire was earning good grades and therefore did not question her teacher. For the most part, Claire would memorize what she was supposed to learn and used it to be successful in her class. Her classmates expected her to be smart and get good grades. If and when Claire did question the teacher, it was usually to get information. She believed that the teacher had the information and could dispense it readily.

In her learning, Claire needed to know ahead of time what she was supposed to learn, so that she knew what to pay attention to in a lecture situation. She wanted to take in every piece of information that her teacher was sharing with her because she was not sure what she would need later. Claire’s learning was based upon what she thought the teacher wanted her to know and learn. It was important for Claire to be able to produce the correct answer on tests and homework situations. Most of the tests were based on the information that the teacher had dispensed.

Claire did display some aspects of a subjective knower. Unlike a received knower who felt that they could not generate facts and ideas on their own, Claire had some confidence that she was able to generate new ideas. However, Claire had not reached the point where the truth was subjectified and personal.
In Claire's science learning, she wanted to make connections with what she was learning to the real world. Her past experiences as well as her current learning situation had not allowed her to make these connections. For Claire, she was satisfied in getting good grades and doing well in her science class. She was not interested in pursuing a field in science and believed that her received knowing perspective would allow her to take from this experience what was necessary for her to be successful in her other interests.

Maureen

Maureen did not fit neatly into any one category of knowing. She found herself moving from a perspective of subjective knower into that of a procedural knower, depending on the activity. Maureen did a lot of thinking in her science class in terms of her learning and participating in class. She was always wondering how certain things worked and how they were going to affect her in real life. She realized that first-hand experience was a very valuable source of knowledge and that the truth was grounded in first-hand experiences of others that were most like herself.

Maureen found the whole nature of her enriched science class to be very intimidating and prevented her from asking
questions as well as answering them. She was afraid of being wrong and being made fun of by the males in the class. There were many times that she did want to ask questions, to help her make connections with her learning, but she held back. During these times, Maureen would demonstrate more of a subjective knowing perspective.

Maureen found herself questioning the teacher as well as her classmates on various issues in science. She learned to trust her inner voice and looked towards others for answers and discussions. She realized that the teacher was not the sole distributor of knowledge and began to rely on her own voice. It was during these times of self-reflection that Maureen took on more of a procedural knower. Belenky et al. (1997) believed that in order for a woman to be completely procedural, she must demonstrate both a connected as well as a separate procedural perspective. Procedural knowers required learning not just the content, but what the teacher was thinking and what the teacher expected her to learn. Maureen realized that in order for her to be successful in the class, she had to learn what the teacher wanted her to. At times, Maureen’s inner voice told her that her ideas and questions were stupid and that they did not measure up to the expectations of her classmates and teacher.
Maureen did demonstrate a full aspect of procedural knowing. Her separate procedural knowing perspective was demonstrated by her critical thinking as well as the way she felt that she was wrong about answers. However, Maureen did not make herself vulnerable to criticism and did feel a personal involvement in her pursuit of knowledge.

Maureen demonstrated a connected procedural knowing perspective in the way that she realized that most of her trustworthy knowledge came from personal experience rather than authorities. When Maureen could personally experience something hands-on, it was much more meaningful to her and allowed her to connect with the information.

Group work was valuable to Maureen if she was allowed to decide who she wanted to work with. This aspect of group work fell neatly into the category of a connected procedural knowing perspective. It was important for Maureen to work with people that were like her so that she could develop procedures for gaining access to other people’s knowledge.

There were a few brief moments when Maureen could be seen to display a constructed knowing perspective as she tried to integrate the knowledge that she was receiving with her day to day experiences. Maureen was very comfortable with the idea that she might discover more than one correct
answer and that science was not about an either/or choice. She was challenged by conflict and contradiction, however she usually did not choose to voice these ideas.

In order for Maureen to fully develop into a constructed knower, she needed to be in a same-gendered classroom. This type of learning environment would allow her to voice her own opinions and to actively engage in discourse. Maureen would begin to realize that knowledge was constructed and that she was an intimate part of the knowledge that she was seeking.

Louise

In my first observations of Louise, I was convinced that she was demonstrating a silent knower perspective. During the course of six months, I saw no interaction between Louise and her teacher and very little interaction with her classmates. Belenky et al. (1997) found that the silent perspective rarely occurred in their work and usually only in cases of abuse.

The silent knower viewed the teacher as the authority and relied on the teacher to dispense the information to her. She appeared invisible and silent to her teacher as well as her classmates. Many of Louise’s experiences in science encouraged a silent perspective and provided her
with a limited opportunity to ask questions. She learned early on that she could be successful by “soaking” up information like a sponge.

Upon further interviewing and discussions with Louise, I realized that she was only displaying a silent behavior and not a silent way of knowing. If Louise was truly a silent knower, she would not even be able to understand the topic or the teacher. She would not be able to understand science on her own and her inner sense of authority would be hidden.

Louise shared with me that she was really a shy person and that usually prevented her from asking questions in class. She also was one of the brightest young women in her class and the most successful. These results would not be from a woman in the silent knowing perspective. A silent knower did not think for themselves and tended to think of themselves as deaf and dumb. Louise did not fall into this category.

Louise fell into the category of a received knower. She was very cautious to listen to the words of others and believed that words were central to her knowing process. She learned by listening to the information that was being produced by the authority figure, in this case, her teacher. Louise believed that there was a right or wrong answer for
each of the problems or issues that she dealt with in her science class. She was very uncomfortable with the idea that there might be more than one correct answer. She had not been able to make connections with what she was learning.

Even though Louise was very intelligent in terms of knowledge, she had little confidence in herself to speak her mind. For the most part, she was very open to take in what others had to offer. She was often relieved to hear others saying the same thing that she would have said. The only time that Louise was observed questioning classmates involved a lab setting. The questions were based on the procedures that her group was following.

Authority figures were associated with her teacher as well as her parents rather than her classmates. Louise equated receiving, retaining and returning the thoughts and words of authority figures with learning. She believed that her teacher was always more or less right and sometimes felt confused if she was asked to be creative in her work. She would rather just stick to the standard format and procedures that she had become comfortable in knowing.

Louise had been able to use her received knowing perspective in this science classroom as well as science classrooms in the past. She sometimes tried to make
connections with what she was learning, but became frustrated and often saw the labs and activities as "pointless". She felt comfortable in her ability to absorb and store the truths that she had received from others. This had allowed her to be very successful in the past and encouraged Louise to continue to be a received knower.

Liz

In most of the learning situations, Liz would be considered to be a received knower, with occasional moments of subjective knowing. During my observations, Liz was very quiet in class and did not question her teacher or her peers. During lab work, a different side of Liz emerged. She became very social and interactive with everyone in the class. Liz was much more comfortable and confident in a less formal situation.

Liz found comfort in knowing that there was only one right answer for her questions. She was very uncomfortable knowing that there could be more than one right answer. She displayed the behavior of a silent knower rather than a silent way of knowing in class because she chose to internalize what she had learned. The internalization of information was connected more with a procedural knower rather than a silent knower. In order for Liz to fully make this internalization of knowledge, she must participate in
the class discussions in order to connect with others. Liz did not participate in class discussions; therefore, she did not fully internalize what she was learning.

In her science class, when Liz did need a question answered, it was strictly to clarify or get information, never to question the authority. This was clearly evident in a received knower. Liz would never question her teacher, nor would she ask him to slow down if he was presenting the information too quickly for her. She was confident, that if she missed the information, then someone else in her class would share that with her.

Liz cared very much what the teacher thought of her and therefore would not ask any questions. It was important to her to get good grades and learn what the teacher had decided that she should learn. She learned by listening to the voices of others rather than herself.

Liz had very little confidence in science, even though she managed to receive good grades. She believed that she did not have a scientific mind and that others in the class knew more than she did. Her inner voice told her that her classmates were better than she was. She was quick to rely on her classmates for the answers to questions that she encountered because she did not trust her own ability to know.
In lab situations, Liz relied on Mr. Hanes to be the authority figure. She believed that he knew more than she did, so he must have the right answer and would provide that answer if she listened long and hard enough. As long as Liz continued to maintain good grades, she would see no reason to question the teacher. She had learned that being successful meant doing what the teacher wanted her to do.

There were moments during the study where Liz was struggling with trying to move out of the received knowing perspective and into a subjective knowing perspective. There were many times when Liz believed that an answer was wrong and started to believe that she might actually have the truth within her. She started to trust her own inner voice, but failed to verbalize this through conversation.

Liz believed that a first-hand experience was very valuable in obtaining information and allowed her to make connections. This was an indicator of someone displaying a procedural connected knower. If Liz was only a received knower, she would not be able to recognize the connections in the knowledge she was gaining.

Activities such as concept maps and interactive computer programs allowed her to tie the information together. These beginning connections that she was making
allowed her to trust her inner voice. Liz was beginning to realize that in order for her to fully understand, she must make the necessary connections.

Liz had not yet realized the power of her own mind and was struggling with taking authority from an external viewpoint to an internal viewpoint. Once this was accomplished, Liz would be able to move on into a procedural knower perspective and take more responsibility for her own learning. Liz would not need to rely so heavily on what the teacher wanted her to know, but rather on what she believed was important. She would be able to listen to that inner voice and gain new confidence in the area of science.

Marie

Marie found herself between a subjective knower and a connected procedural knower. She listened to her inner voice instead of listening to external authorities. She was very comfortable asking questions and did not view herself as being shy in any of her classes. For the most part, Marie believed that truth resided within the person; however, she would not risk answering questions if she felt there was a chance that she might be wrong. Marie felt conflict within herself in attempting to answer questions and participate in class discussions.
Procedural knowers must think before they speak because their ideas must measure up to certain objective standards. Marie commented that one of her reasons for not speaking up in class was that she needed time to process the information. The dominant males in her class did not give her time to do this and she became frustrated with herself. Marie also believed that there were many ways to solve a problem and looked for connections in her learning. She was not comfortable with looking for a single right answer. In this respect, she was on her way to becoming a connected procedural knower.

In being a connected procedural knower, Marie recognized that the most trustworthy information and knowledge that she could gain came from personal experience rather than authorities. Her early experience in science provided her many opportunities for hands-on learning and in order to get the most out of learning she needed to be involved personally in her learning.

Working in groups was very helpful to Marie because she could connect with others ways of learning. She also found that her friends could explain the answers easily for her and that groups were quicker because of the interactions that took place. These interactions allowed Marie to
internalize the information and develop a deeper understanding of the topic. This was further evidence of a connected procedural knowing perspective.

According to Belenky et al. (1997), in order for a woman to be considered fully procedural, she must also demonstrate a separate procedural knowing perspective. In Marie’s experiences, she did not demonstrate a separate knowing perspective. Making meaning out of her science class was very personal and she did feel a personal involvement in her pursuit of her knowledge.

Melissa

Melissa, for the most part was a connected procedural knower. There were times when she demonstrated a constructed knowing perspective, but only on several instances. She was very outgoing and vocal when the topics were of interest to her. In observing a lesson related to biology, Melissa was fairly quiet and not interested. When the subject matter turned to earth science, Melissa was very vocal and did not hesitate to question her teacher or other classmates.

In order for Melissa to know whether something was true or not, she liked to be able to observe and analyze the information. By doing so, she was able to internalize the information and make the necessary connections so that she
remembered and was able to apply the information to other situations. Many of the hands-on activities allowed Melissa to connect with her learning and to see how the topics flowed together.

Melissa demonstrated a connected knowing perspective by the way that she questioned her teachers when they told her something. Melissa was very challenged by conflict and contradiction and loved to argue her point and state her opinion. This was especially evident when her teacher presented her with the concept of evolution. Melissa argued that many of the topics in science were just theories and you did not really know what all the facts were. It is up to each individual to decide for him/herself what was fact and what was theory. She was very good at tying together small pockets of information in order to make connections with the information.

Melissa had also abandoned the either/or type of thinking which was evident in a connected procedural knowing perspective. She liked to examine each issue independently and form her own opinion. By doing so, Melissa was able to integrate the information that she was learning and make it real to her. She very much believed that all knowledge was constructed and that she was an intimate part of that knowledge.
Melissa loved to work in groups because it provided her with an opportunity to verbalize some of her thoughts on different topics. In voicing her opinions, Melissa realized that not every one thought along the same lines that she did. The difference of opinion enabled Melissa to strengthen her viewpoints and understand other group member’s ideas.

In participating in group work, Melissa found that it was much easier to solve problems and discover answers than to work alone. Most of these successful group experiences had taken place in groups where she had known the other group members really well. This also provided evidence of a connected procedural knowing perspective. Without making connections, Melissa found the information and knowledge boring and unrelated to what she was doing.

In the enriched science class, Melissa was the most likely to participate in classroom discussions. She was not content with sitting and letting everyone else do the thinking for her. She needed to make her learning personal and felt very strongly about being able to “think” about the information that she was learning. She was not afraid to take risks or to challenge her teacher or classmates. Melissa provided much evidence for demonstrating a connected procedural way of knowing science.
Summary

The women’s ways of knowing in the science classroom were very different for each of the women in the study. Depending on the activity, a different way of knowing was displayed. The evidence suggested that there were a variety of ways that women learn in the science classroom. These ways of knowing and types of activities that make science more female-friendly are discussed in chapter 5.
CHAPTER 5
DISCUSSION

As I evaluated the purpose of exploring women's ways of knowing in a science classroom, I found that the study had merely skimmed the surface as to how women learn. I found myself being reflected in many of the women's ways of learning and their actions in the science classroom. Many of the struggles that these women experienced in a science classroom, I too have experienced. Our similar experiences encouraged me to continue to find ways to make women more comfortable in a science classroom and to believe that they could do science.

My Experiences

Past Science Experiences

I did not remember much about my science experiences during elementary, middle or high school. I found myself wondering how I came to be a science educator with a strong interest in science, despite these early experiences. I was the first in my family to attend college, first to earn a degree, and to earn a graduate degree.
My main interest going into college was in the area of health and physical education. I wanted to major in a field where I knew that I could be successful. I liked science, but I was scared that I would not be able to be successful in science and that it would be too tough for me to handle. I had no confidence in my ability to "think for myself" or believe that I could do science. In my pursuit of health and physical education, I had a woman professor who taught anatomy and kinesiology as part of our physical education requirement. To my knowledge, this was the first woman who had taught me science.

During these courses, I found that I was able to make real connections with the science that we were doing and found myself wanting to pursue it further. Her guidance and encouragement gave me the confidence that I could be good at science. After my sophomore year, I decided to pursue a degree in science and began taking summer classes in order to make that happen.

Most of my science experiences encouraged a received knowing environment. The majority of the classes were lecture based with much memorization. During these experiences, I found it very hard to make connections with what was being taught. I did much reflective thinking during these times and found myself making and establishing these connections without the help of the professor.
As a science educator, I firmly believed that everyone could do and learn science. I believed that women could do science and be very successful at doing science. This was possible if they were able to make the necessary connections that made it real to them. I had experienced many women students who had been unsuccessful in science in the past. These women had been told by parents and guidance counselors that they were not good in science. Over the years, these women believed that they could not learn science.

I believed that it was very important to make available positive role models in science for women in high school. I found it interesting that the first mention of Rosalind Franklin and her contributions to DNA happen during the pursuit of my Ph.D. at The Ohio State University. Many of these women in high school did not know of women that had been successful in science or some of the struggles that they had to go through. In turn, they were unaware of the many contributions that women had made in the field of science.

In my learning of science, I needed hands-on activities to make valuable connections with the knowledge that I was learning. If connections were made and women could see these connections, interest was created and encouraged them to be more active in their learning. Learning to me meant
that one was able to apply what they learned in the classroom to real life applications. If more women could see and make these kind of connections, science would be seen as something that was valuable to them and something that they could be successful in.

Throughout my early education and career, I could be described as a received knower. Many times I demonstrated a silent knowing behavior by being quiet in most of my classes but still receiving and understanding the knowledge that was being presented. I found myself relating to most of the "quiet" women in this study. During my education, I often wondered if what I had to say was important or if my question would be a dumb question. Many times I could relate to Louise when she said, "Someone else will usually ask the same question that I am thinking so there is no reason to ask". It had only been recently in my pursuit of my Ph.D. that I had gained confidence to ask questions and question some of the information that my authority figures had given me.

Women's ways of knowing had helped me to understand the women in the study as well as myself. My eleven years of experience teaching science and working with women had provided me with evidence of how women learned science and
how they could be successful. The learning environment and
the past experiences of these women helped to determine the
ways that they learn.

Women’s Ways of Knowing Science

The Women’s Ways of Knowing Science helped me to get a
tough handle on how women in a high school setting could
learn and be successful in science. During this research, I
used several research questions to help me explore the
avenues that women learn science. I asked about the ways of
knowing science that the women in this class had developed
in the past and how these continue to develop in order to
learn science. I was interested in knowing how the women of
this study maintained or moved away from a particular way of
knowing and how they went about doing this. I asked how the
various ways of knowing related to the women’s feeling of
confidence in a science classroom. I also wondered how high
school women learned science and how they problem solved to
arrive at certain answers during lab situations.

As a group, I found that the women of this study did
experience all of the Women’s Ways of Knowing perspectives.
Each woman individually experienced several of the knowing
perspectives. Most of the women moved from one way of
knowing to the other depending on the type of activity that
was being conducted in class. For example, one of the women
might be a received knower during a lecture, but during lab work provided evidence of being a subjective knower. In identifying these ways of knowing, some of the women were very easy to identify, while other women made it difficult to determine the type of knowing at the time.

Many of the women were not aware of the movement from one type of knowing to the next. The women had "performed" this way for many years in their science classrooms and they did not even realize that they did not ask questions. They had become accustomed to moving from one way of knowing to another and almost did so without thinking about it. Most of the times, the women moved from one way of knowing depending on the type of teaching method used in the classroom.

Many of the women displayed different types of knowing in their first year science program as compared with their present classroom. This present classroom, with the dominant males, altered many of the women's ways of knowing. Many became received knowers because they were not able to process the information quick enough to outspoke the dominant males. In a same-gendered classroom, many of these women might have been able to move into a constructed knowing perspective or at least a procedural knowing perspective.
Several of the women were not comfortable with the ways of knowing that they were demonstrating in the classroom, but found themselves not being able to move out of this pattern that they had established. There were internal struggles taking place within many of the individual women. They were too concerned with what the teacher or their classmates would think of them. Others did try to move out of their established way of knowing only to be turned back to where they came from by either the teacher or the dominant males in the class. These women’s ways of knowing both contributed to as well as hindered their ability to learn science.

Most of the women felt that their current science class did not allow them to connect with the science that they were learning. The women expressed the need to be able to connect with their learning. This conflict caused many women to remain as received knowers. In order to be successful in their class, they wanted to know what the teacher wanted them to know, even if this meant not making connections. With the few women that were able to make connections on certain activities, movements through the ways of knowing seemed very natural and easy for them.

Much of the past experiences for these women had been in very traditional science classrooms. These classrooms usually encouraged the received knowing perspective.
teacher was the dispenser of knowledge and the authority figure in the classroom. Many of the women commented that they were not able or not encouraged to do much thinking for themselves. This conditioning over the years encouraged them to be comfortable with this way of knowing and realized that they only needed to memorize what the teacher thought was important in order to be successful.

**Learning Science**

In the type of learning environments that these women had been a part of, how did they handle the tensions and conflicts that arose in a science classroom? These nine women have had a past history of being very successful in science. It might be that they had adapted their ways of knowing to fit the particular learning environment that they were presented with. How had they been able to do this when most of the learning connections had not been made available to them?

Each of these women had displayed different types of knowing at different moments in the study. The women, as well as myself, were not really clear how and why they moved from one way of knowing into the next. At times, they moved because of a certain activity and at other times they moved due to a new awareness of the learning process. Maureen became more aware of her actions in class and began to find ways to move into another way of knowing and experiencing
science. Many factors attributed to the women’s ways of knowing, such as personality, type of teacher, teaching method, gender expectations, members in the class, as well as the women’s need to be successful in science. Two of the women found themselves in an environment that was not suitable for their way of knowing and chose to move into a different environment to encourage and develop their way of knowing.

Each woman of the study had developed their way of knowing in such a way that allowed them to be successful. If connections needed to be made, some of the women would make the connections. If they needed to memorize information for the teacher, that was what the women did. Each of the women had figured out for herself what she needed to do in order to get the good grades that everyone expected from her. For some of these women, this type of learning pattern did not allow them to further develop their ways of knowing science.

Most of the women in the study believed that group work and cooperative methods were beneficial. There were still a few women who had a bad experience with groups and would prefer to work alone. Katie believed that working in groups would just slow her down whereas for the other women, group work allowed individuals to share ideas and helped clarify their thinking. If group work was to be successful, the
women preferred to chose the people that they were working with. This method prevented the women from being stuck with people that would make them do all of the work.

The lab activity that the women performed provided a good example of how collaborative group work could be effective. In two of the three groups, the women discussed possible answers and reasons for the answers they discovered in the lab. The discourse that was generated in this problem-solving activity provided the opportunity for the women to confirm or disconfirm their answers in a non-threatening environment.

For most of the women, lecturing was useful if only for a few minutes. It was much more important for these women to be able to experience hands-on what was happening. This gave the women a chance to actually see what was happening rather than just to read about it. The women learned and retained more if they were given the opportunity to analyze and observe rather than take notes. Most of the women commented that they tuned out a lecture because it was boring and did not bring the science to life.

The use of video tapes in the classroom was not a strong choice for these women. Most of them commented that they did not get anything out of the video’s. The journals reflected that they had seen too many video’s and that they really did not learn much from them. The few occasions when
the teacher made them complete a worksheet, forced them to pay attention to the information and they felt that they got more out of the video. If the video was current and they could relate what was happening to everyday life, they did express some interest.

The women seemed to enjoy the interactive CD-ROM presentations made by their teacher as well as the group interactive computer programs. This provided the women with a different avenue of learning that made connections with the materials that they had heard about in class. The women did comment that they were expected to complete these activities at a very rapid pace and that they were not given the appropriate time that it would take them to actually process the information. One group commented that they were just filling in the answers and not really thinking about them, they could not process what they were learning. Many of them did not do well on the test because they could not connect or process the information.

In eleven years of teaching, I had witnessed the fact that women were more successful with the interactive types of teaching methods presented above. Even the women who had not been successful in the past, seemed to have their interest peaked when presented with activities such as these. The women needed to know that what they were learning was something that was valuable to them and be able
to see why it was valuable. When this happened, the women were able to make real connections and make the learning interesting and exciting.

All but two of these women had Mr. Smith during their freshman year. The women all recalled very positive learning experiences during the first year. Mr. Smith made an effort to call on the women in his class, even if they did not have their hands raised. He commented that many of the women had become so accustomed to saying "I don't know" that they would not even try to respond to his questions.

If a women in Mr. Smith's class responded with "I don't know", he would ask her to think about it and that he would wait a few minutes to give her time to think about her answer. The room stayed quiet and eventually he called on another woman and then another, no matter how many of the guys had their hands raised. The women in the study believed that this was a very non-threatening environment and provided them with the opportunity to think about their answer before responding. It also sent a message to the males that the women in the class were active participants too.

Mr. Smith did not just try to call on the women in the class, but had also used other effective strategies that encouraged the women to be vocal participants in the class. For instance, Mr. Smith had called on different regions of
the class where there was not any order, but just a random picking of those people. He had also discovered that sometimes the eye contact from the teacher could be very intimidating, so he would look around the room when the women were thinking.

These methods had been very effective and the women whom he had in class the first year commented on how they felt comfortable participating in discussions and asking questions. Without really knowing it, Mr. Smith encouraged these women to move into another way of knowing science and to develop their confidence in science.

**Purpose of Research**

The purpose of the research was to look at women's ways of knowing science in an integrated enriched science program. These women had, for the most part, always been successful in science. The research and the results were not meant to be generalized to other populations of women in science. These results could only be discussed in terms of the nine women of the study.

The study had shown that if the women did not have an opportunity for making connections with the subject matter that they learned and if they could not relate the science to their life, they might remove themselves from science. Even though most of the women in the study did not see themselves pursuing a career in science in the future. They
were only taking the enriched course because they were good students and that was what was expected of them. If more of these women had the opportunity to make connections in their science classroom, many more of them would be interested in pursuing a science-related career.

In most of the traditional science classrooms, the decision-making power usually remained with the teacher. This type of a structure encouraged the women to remain silent and allowed the teacher to dispense knowledge that they felt was important. The much needed empowerment of the students was unlikely to happen. Teachers needed to give the students the opportunity to explore their interests and expand upon their ways of knowing science. By making room for experiential differences, the teachers were providing the students with a sense of ownership for their own learning.

Classrooms that allowed women to pursue questions openly and allowed them to look for meaning rather than a correct answer encouraged women to take charge of their own learning. Examining and analyzing data to look for evidence in a science classroom also encouraged women to change their views about science. In many cases, the women began to like science because they could establish meaningful relationships with the content in science.
The women of the study disliked teaching methods that isolated them from their classmates. These included methods such as reading from a textbook or taking notes while a lecture was being presented. Women would much rather prefer instruction that permitted them to interact with their classmates. These methods could include groupwork or small discussion groups on current issues related to science. Belenky et al. (1997) believed that relational values such as cooperation, working with people and helping others are characteristics of women in general. The women in the study would agree with those characteristics.

**Implications for Women High School Students**

What does this mean for the average woman in a high school science class? In most cases, the ability to move from one way of knowing to the next was within each woman in science. In many cases, these women had not been provided with an environment that made them aware of their way of knowing or an environment that encouraged a growth of their current way of knowing. Many of these women were involved in traditional classrooms that encouraged only one way of knowing, a received knowing perspective.

Many of these women in science did not realize that they had a voice and that they had control over being able to learn science. All women could be successful and learn science. The most crucial factor involved in their success
was their awareness that this was possible. Teachers, parents and counselors had very important roles in determining the confidence of these young women. The women needed a learning environment that made women aware of their ways of knowing and provided plenty of opportunity to move into different ways of knowing. At times, the women needed encouragement and direction into making the connections happen.

By making women aware of their ways of knowing and how they could be successful in a science classroom, new confidence would emerge in these women. They would begin to understand the power of their minds and their ability to process and connect with the content that they were learning. As the women’s ways of knowing began to grow, she would be able to make more active choices to allow her to learn in ways that were most beneficial to her. No longer would she be content to be only a received knower, but would want to discuss and build on her knowledge.

My awareness of women’s ways of knowing had encouraged myself to become more actively involved in sharing with other women in my classes about their ways of knowing. More teachers needed to be aware of the types of learning environments that were conducive to women’s ways of knowing to encourage women in science. As a woman science educator, I had a great opportunity to provide such an environment to
the other women students whom I had in my classes and to encourage them to share the information with their friends in other classes.

Critical discussion in a science classroom was a very necessary element in order to have women think and process the information. Analyzing the data and then being able to interpret what was presented helped them to interpret what they had read. The women that were always looking for the right answer needed to be provided with opportunity to explore several possible explanations and to develop their own inner voice that helped them clarify what was possible. The women needed to realize that the teacher was not the authority figure, but merely a facilitator of the knowledge that they themselves were capable of producing. Many of these traditional ways of knowing had been embedded in these women for many years and change would not come easily. However, in order for science to be effective for all students, women’s ways of knowing science needed to be examined and incorporated into the high school curriculum.

Recommendations for Science Teaching

Throughout the study, several recommendations for science teaching had become obvious. First of all, Science needed to be taught from more of a constructivist point of view. In other words, the teaching needed to begin with what the women already knew and the learning needed to take
place within the level experiences of the women. This would help the women in the class make connections and see the real life applications that science had.

Second of all, women needed time to process information and develop more of a personal bond with the information that they were learning. One way to accomplish this might be to assign longer projects or provide more time to do activities. This would provide an opportunity for the women to take a more vested interest in the content and allow them to form a personal bond with their learning experience.

Thirdly, the classroom environment needed to be supportive and cooperative. The women needed to feel non-threatened in asking and answering questions as well as questioning authority figures. All ideas and suggestions needed to be viewed as important and all members of the class treated equally.

Other suggestions for encouraging women could include more projects that were open-ended and that allowed the women to design the type of project that they would like to study. For instance, the women in the study tended to like to work with other women in the class while many of the males preferred to work individually. Projects could be open-ended enough to accommodate both learning styles.

All women needed to be exposed to different ways of knowing. Many of the women of the study became very
comfortable with their way of knowing. The only way that growth could continue was to experience other ways of knowing. By experiencing other ways of knowing, women began to develop intellectually as well as feeling ownership in their learning.

The results of the study could provide valuable insights into teaching methods for the classroom teacher as to how students learn. The Women’s Ways of Knowing framework could be seen as a catalyst to the concept of learning styles. Learning styles themselves could provide for the teacher a standardized version of how students learn. However, this approach alone might encourage the student to stay within a particular “way of knowing”.

If the teacher were able to combine the information gained through the women’s ways of knowing approach with the learning styles approach, they would be able to effectively help move the student into different ways of learning. This would be important in exposing the student to different ways of learning and enhancing the educational experience of the student. Both of these methods could actually assist the teacher in designing approaches for a curriculum that could reach all of the students in the class.

Much of what happened in the classroom, depended upon the teaching methods that the teacher was using. Most of the women felt more comfortable with the type of methods
that had been used in their year one class. It was important for teachers to realize the different ways of knowing so that they could encourage the students to move into different ways of learning and expand their knowledge. Teachers as well as future teachers needed to be exposed to these different ways of knowing as well as the type of learning styles that their students might display in order to meet all of the needs in the classroom.

Same-gendered classrooms could provide an opportunity for the women students to learn in a non-threatening environment. These same-gendered classrooms provided the women the opportunity to perform lab activities, use technology, and to participate in discussions in a non-threatening environment. The skills learned in this type of a classroom would be valuable for preparing the women for the real world and to develop an assertiveness that would allow them to be more successful in life.

The learning that took place in a same-gendered classroom would be dependent upon the type of teacher and the type of methods that were used in the class. A good teacher who used the women’s ways of knowing as well as a learning styles inventory, might be able to produce the same types of results in a co-educational classroom. Regardless of the situation, all teachers needed to be more aware of the types of students that they had in their classrooms and
work to move them into the next level of learning. Too many of the students had become comfortable with a particular way of learning and therefore prevented them from moving to another level of learning.

**Further Research**

In order for the research to be useful in a high school setting, teachers as well as women students needed to be aware of the different ways of knowing science. More research was needed in looking at how these ways of knowing could be incorporated into a K-12 curriculum. Many of the ways of knowing that these tenth grade women were displaying had been embedded since early elementary school. If change for women in science was going to occur, the change needed to happen early-on in the educational process. The teachers could bring about these changes, but only if they were provided with the evidence as well as practical ways for bringing about change in young women’s lives.

**Researcher Reflections**

As a researcher, I experienced a few minor barriers in sticking to my research plan to explore women’s ways of knowing at the 10th grade level. One of the barriers involved the teacher of where the research had been conducted. The teacher was a colleague of mine and the research became a sensitive area due to the negative comments that were made by some of the women concerning the
teacher. I needed to stay focused on how the women learned science rather than the way the teacher taught these women. Some of the women’s comments raised ethical issues that had to be dealt with on an individual basis.

Throughout the study, I did manage to stay on course with my research plan. The research questions were open-ended enough that they allowed the women to express how they felt about learning science. The women seemed to be fairly comfortable in answering the interview questions. Most of the women had realized what they needed to do in order to be successful in science. For most of the women, this involved remaining a received knower and learning what the teacher wanted them to learn.

The women of the study had much parental support and encouragement when it came to learning science. The women believed that they were intelligent in all areas of school and had success in science at the lower grade levels. The study helped me examine how women at the other end of the scale might improve in the area of science.

In my experiences, I worked mostly with those women that had not had much success in science in the past. The study gave me new hope for these women who had not experienced success before. I realized how important processing time was for the women in science as well as how important hands-on activities were. In order to encourage
other women and make them excited about science, the recommendations that the women of the enriched science class needed to be incorporated at all levels of science. It was my hope to be able to share some of these recommendations with other science teachers to help make science classrooms more female-friendly.
APPENDIX A

INITIAL REQUESTS AND LETTERS
Oral Consent Form

We will be conducting a science education research study here with some of the females in the class. This study is conducted by Dr. Rosanne W. Fortner, a professor in the School of Natural Resources at The Ohio State University, and a doctoral student, Karen L. Kochheiser. The purpose of this study is to understand how females gather information and data and how they use this data in a science classroom. The participation of this study is strictly voluntary. You can decline to answer any question in the study or withdraw at any time.

You will be given a survey to find out where and how you gather information and data. Based on your responses to the survey you completed, I have asked you to participate in a set of interviews to get a more detailed look at how you gather data. I will be taping our conversation so that I can make a complete copy of what we say later. No matter what, I will not use your real name in anything I write to describe our conversation. None of this will affect your grade in any way, nor will I share anything that you say with any other teachers or other individuals. You will not be identified in any way in my final report, and I will destroy any documents identifying you when I have completed the project.

If this is agreeable to you, I will need you to sign this document indicating that you understand what I have just said and that you freely agree to participate.

Participant Signature _______________________
Date______________

Witness Signature _________________________
Date _______________
Dear (Parent name),

As part of my work leading toward a Ph.D. in Science Education at The Ohio State University, I am conducting an educational research project. This study involves examining the ways that female science students gather data and how they use this data to be successful in science.

I would like to take this opportunity to invite your (daughter) to participate in this study in a special way. I would like to conduct several interviews with your daughter to find out where she goes to collect information or data concerning science and how she decides what information will be useful to her. I will also observe her in the classroom setting participating in science activities and interview her as to how she decided where to go for information.

Each interview will last approximately 15-20 minutes and will involve questions related to females data seeking processes. The interviews will be audio taped in order to allow the conversations to be transcribed to paper. These interviews will in no way alter or affect the traditional classroom environment. The research will take place January 1997- May 1997.

I want to assure you that your participation in this activity is completely voluntary. No part of the interview process will be considered as part of your child’s grade. All responses will be strictly confidential. No individual will be identified in any reports or evaluation and no individual responses will be shared with any other person, including other teachers. At the end of the project, all identifying documents will be destroyed. If you agree to participate in the project, I will need you to sign the attached consent form and return it to me at your earliest convenience. If you have any questions, please feel free to contact me at 292-1078. Upon completion of the project, I will be happy to share my results with you.

Sincerely,

Karen L. Kochheiser
To: Dr. Gerald Prince-Worthington Schools
From: Karen L. Kochheiser
Re: Dissertation Research

Dear Gerald:

On November 22, 1996, I met with Bill Northrup and Ron Pilatowski at Thomas Worthington High School to discuss my dissertation research. I am currently on sabbatical leave to finish my Ph.D in science/environmental education. Both Bill and Ron thought that my dissertation topic sounded very interesting and felt that the results would benefit many of the staff in our district.

In my research, I am looking at how women gather information and data, how they find it, how they decide what information to use, and how this relates to success in science. I am going to use Ron’s eighth period enriched BESS class.

Bill asked me to write a short note to make you aware of this process. I would love to share my results with you and anyone else that might be interested.

If you have any further questions, or if there is anything that I can do to further explain this, please feel free to contact me.

Thanks for your time.

Sincerely,

Karen L. Kochheiser
(h) 548-4276
(w) 292-1078
APPENDIX B

INTERVIEW PROTOCOLS
Interview Protocol: Introduction

Women's Ways of Knowing Science

Main Question: Would you tell me about your past science experiences? Types of science classrooms that you have been a part of.

Follow up on:
- feelings and emotions
- specific instances, types of learning situations
- definitions of "good" science classes

Focusing Topics:
- What is your first memory of science?
- What is your most significant memory of science?
- Do you have any memories from learning science?
- How would you describe information gathering for this science class?
- If you were given a research project, where would you go first to find the information? Why would you go there first?
- If you were given a homework assignment that you did not understand, where would you go to gather or collect the information? Why?
- If you were doing a lab with all females and were stuck on a question or procedure, what would you do?
- If you were doing a lab with both males and females and were stuck on a question, what would you do?
- What role does your teacher play in deciding where you go for information?
- Once you have found data or information, how do you decide what to use and how to use it?
Interview Protocol # 2
Women’s Ways of Knowing Science

1. Give me your definition of learning.

2. How do you learn science?

3. Describe what you would consider to be a really good science lesson?

4. Are you comfortable, if you would come up with more than one way to solve the problem?

5. How would you describe a bad science lesson?

6. Do you find yourself actively participating in discussions if they take place in your class?

7. Describe characteristics of a good science teacher.

8. Describe characteristics of a bad science teacher.
Group Interview Protocol

The group interview was chosen for the purpose of drawing forth elaboration on topics that emerged during the observations or individual interviews as well as providing an opportunity for the participants to stimulate each others' memories through the open discussion of experiences. The group is asked an opening question that was determined from the previous interviews. Themes emerging from the initial interviews that reflect the Women's Ways of Knowing formed the basis for questioning.

Questions:

1. Has participating in this study changed or caused you to re-evaluate how you learn science? If so, what kind of changes or new awareness has it caused or brought about?

2. Most of you stated that you learn best from hands-on. Why do you think this is so?

3. Do you think that your ways of learning science has changed over the past couple of years? If so, how?

4. In this science class, do you find yourselves doing a lot of thinking for yourselves or is it teacher directed?

5. If you could change how science is taught now, so that it would benefit other women, what suggestions would you have and why?

6. Other comments about your learning science or this study?
Post Group Interview Follow-Up

Women's Ways of Knowing Science

Name _______________________

Please respond to the following questions. Feel free to use the back of the paper or additional paper if you need more space.

1. Is there anything you would like to have added to the discussion, but did not have the opportunity to add?

2. Is there anything you would like to have added to the discussion that you would rather not share with the others?

3. What would you like to know about you being female and trying to learn and be successful in this science class?

4. Any additional information that you would like to provide?
Journal for Women in Dissertation Research Study

For a period of approximately four weeks, I would like you to take a few minutes each day and reflect on your science class. Do not spend time telling me what you actually did in class each day, but tell me how you felt. Keep in mind, that I am trying to find out how you learn science. Tell me about "good" lessons or activities or "bad" lessons or activities. What made them good or bad. Your feelings and thoughts are VERY important to this study. Thanks again for your time.
Interview Questions for Current Science Teacher

1. The women in this class seem very quiet and do not really seem to participate verbally in class. Has this been the general trend all year? Does it depend on the subject matter? any insights or feelings as to why the women are so quiet?

2. In terms of asking questions outside of class, do the women students approach you seeking "help"? If so, do they seem comfortable asking questions?

3. Have there been situations when you have called on the women in the class when their hands have not been raised? If so, could you describe several of these situations?

4. How would you describe the women’s work ethic on labs in your class?

5. Any other insights as to how you feel women learn science best?

6. Grades that the women in this class earned for the first semester.
Interview Questions with Previous Enriched Science Teacher

1. Do you think that women learn science any differently than the males in your class?

2. Do you find that the women raise their hands a lot or do you usually have to call on them?

3. Can you briefly comment on each of the women and how they acted in your enriched class last year? Work ethics, grades, participation, behavior, etc.
Lab: Floaters and Sinkers

Developed by the National Association of Geology Teachers
Ward's Natural Science Establishment, Inc. Rochester, NY
Monterey, CA

Continents and Ocean Basins: Floaters and Sinkers

Introduction:
Why does the earth have high mountains and deep ocean floors? Why aren't the continents at the same level as the ocean floors? Why isn't the earth all covered with sea water?

Scientists have developed ideas about the inside of the earth. Their ideas come from a study of earthquake waves and from a knowledge of what happens to rocks under high temperatures and pressures. The earth's interior seems to be arranged into a series of shells. The outer shell, called the crust, is the shell we live upon. It is 12-60 km thick. It is thought to be composed of a hot, solid rock. It probably is capable of flow at very slow rates, much like a candle left in the sun. Below the mantle, and in the center of the earth, is the core. It is believed to be composed of a mixture of iron and nickel.

In the 1950s, Congress funded a study called the Mohole Project. Its purpose was to "look under" the crust to see what the upper part of the mantle was really like. To find out, it would be necessary to drill through the crust of the earth and obtain samples of the material found below the crust. In order to keep the cost down, it would have to be drilled where the crust was thin. Would this be on the continents or in the ocean basins? This module will help you to understand why the scientists decided to drill in an ocean basin.

Objectives: After you have completed these activities, you should be able to:
1. Identify the conditions under which one substance will float in another substance.
2. Predict the movement of the crust of the earth when material is added to, or subtracted from, parts of the crust.
3. Predict the relative thicknesses of parts of the earth's crust from a knowledge of average densities and elevations.

Procedure
Part A: Materials: balance and two blocks of the same size but different densities.
1. Your teacher has given you two blocks of wood that are of a similar size but different density. The density of an object is its mass (approximately its weight) in grams divided by its volume in cubic centimeters. Figure out the density of each block of wood.
   Block 1 _______
   Block 2 _______
2. Which block is denser?
3. Water has a density of 1.0 gm/cm³. Will the blocks float in water? Which will float higher? Why?
4. Fill the pan with water. Place the two blocks in the water. Were your predictions correct?
5. Alcohol has a density of 0.8 gm/cm³. This is less than the density of water. If you placed your two blocks in the alcohol, would they float higher in the water, lower or sink? Why?
6. What would you expect to happen if you placed your two blocks in a liquid, such as syrup, that had a higher density than water? Would they float higher or lower than in water? Would one block float higher than the other?
7. What would happen if you put a much denser material, such as iron, in water? Explain.
8. Thinking back on steps 3 through 8, consider the conditions under which one material will float in another material.

In step 8, you have described one part of the general principle of buoyancy; that is, the conditions under which one substance will float in another substance. You can probably think of many examples of buoyancy: a rising balloon filled with hot air or helium; a cork bobbing on the water when you go fishing; your ability to float when you go swimming. Buoyancy also operates in the crust and mantle of the earth. Geologists call it isostasy. After you answer questions 9 and 10, you will go on to study isostasy in the next part of this activity.
In this activity the blocks of wood and the water will represent the earth's crust and mantle. The upper mantle is thought to have a density of 3.4 gm/cm³. The density of the crust varies. Below the ocean basins it is about 2.9 gm/cm³. Below the continents, however, the crust averages about 2.7 gm/cm³.
9. Which is denser, upper mantle or crust?

10. Which of your two blocks could represent ocean crust? 
Which could represent continental crust?

Procedure
Part B: does the earth's crust float?
Materials: Five square blocks of the same density with two of the blocks a smaller size, for each group.
Along the margins of some continents, offshore, thick layers of sediment pile up. In some cases in the past, these deposits have been many kilometers thick. Later, the layers may have been bent, broken, twisted, and even changed into metamorphic rock. This is the way that mountains such as the Alps and the Andes are thought to have formed. These mountains rise very high above the surrounding continent. After millions of years of erosion by wind, water and ice, they remain high. Why is this? Can you use isostasy (buoyancy) to explain the elevation of mountains?

In the next several steps, you will use wood blocks, all equal in density. Stack the three larger blocks one on top of the other and place the stack in the water. This stack will represent mountains, and the water will represent the earth's mantle. Place one of the remaining two blocks on one side of the mountain, and the other on the other side. These two blocks represent plains, or the lower areas that lie along mountain chains. Draw a cross sections (a side view) of the plains, the mountains, and the mantle. How does the amount of mountain above the upper surface of the mantle compare with the amount of mountain in the mantle? Is this proportion the same for the plains?

2. Carefully remove the top block from your mountain. Describe what happens to the remaining blocks in your mountain. How has the mountain elevation changed compared with the plains? How has the mountain elevations changed compared with the mantle? Has the proportion of wood above the mantle (water line) changed, compared with that below the mantle?

3. Now remove the second block from the mountain. Describe what happens. Draw a cross section of the plains, mountain, and mantle as they now look.

4. In steps 2 and 3, you have simulated the results of erosion on mountain systems. The blocks you removed represent the rock material removed by streams and glaciers.
What would you expect to happen to rocks in a mountain range as the surface rocks are removed by erosion? Does this help to explain why mountains remain high for long periods of time? When would you expect mountains to be at the same level as the surrounding plains?

5. Take the large block of wood (representing a continent) and place it in the water (mantle). Place the small block (a mountain system) on top of the continent. Why did the continent tilt?

In reality, of course, a continent on earth does not tilt because it is not rigid enough. Instead, it bends.

6. Now place a second small block below the continent directly under your mountain range. Note that this second small block is the same size and density as the mountain range. Describe what happens to the continent.

In both steps 5 and 6, movement occurred because of the added mass of the mountain block. In step 5, the continent sank enough to balance the added mass. In step 6, you placed an equal mass and volume of material below the mountain system to form a root which then rose to balance the added mass of the mountain system. This latter situation is fairly close to what occurs in the real world.

7. Examine the cross section that you drew in step 1, Part B. label the mountain root. Now look at the cross section from step 3, Part B. What happened to the mountain root from step 1 to step 3?

Procedure:

Part C:

Because of the graphing in this section, the students were not asked to complete this part of the lab. It was too difficult for them to try to verbalize the graphing aspects in this section.
References:


