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FEMINIST TEACHER RESEARCH AND STUDENTS' VISIONS OF SCIENCE: LISTENING AS RESEARCH AND PEDAGOGY

By

Elaine Virginia Howes

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ABSTRACT

FEMINIST TEACHER RESEARCH AND STUDENTS' VISIONS OF SCIENCE: LISTENING AS RESEARCH AND PEDAGOGY

By

Elaine Virginia Howes

In this dissertation, I bring together methodologies deriving from teacher research and feminist research to study students' visions of the content and processes of science. Through listening intently to students' talk and studying their writing, I address the following questions:

- What can intensive listening to students tell us about students' thinking and beliefs concerning their images of science as a social enterprise?
- What kinds of classroom situations encourage and support students' expressions of their lives and beliefs in connection to science?
- How can feminist theories of education and critiques of science inform our efforts for "science for all"?

This study is organized by focusing on the connection between national standards for science education and feminist theories of pedagogy and feminist critiques of science. From this starting point, students' ideas are presented and interpreted thematically. The resonances and dissonances between students' ideas, standards' goals, and feminist theory are explicated.

Current best practice in science education demands that science teachers attend to what their students are thinking. For this dissertation, I have taken a perspective that is slightly askew from that of listening to students in order to support or challenge their thinking about natural phenomena. During my teaching, I set up situations in which

students could speak about their images of science; these situations are integral to this study. My research goal was to listen in order to learn what students were thinking and believing -- but not necessarily in order to change that thinking or those beliefs.

My work is meant to cultivate common ground between feminist scholarship and science education, while deepening our understanding of students' thinking about the activities and knowledge of science. I hope that this dissertation will open up conversations between science educators and their students around issues concerning students' relationship to science, and their clear-eyed view of its current and potential role in our egalitarian democracy. The exploration of our students', as well as our own, images of science as a social enterprise are central to any effort that claims to make science education welcome to all American students.

Dedicated to Emily, my parents, and Bill.

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My parents, Ruth Ostrander Howes and Robert Craig Howes, taught me to love words, learning, and reflection. It is not possible to describe the power with which their intellectual lives have shaped mine. I will always be grateful for having grown up in a household where things of the intellect were valued, books spilled out of shelves and closets and birthday packages, and scholarly conversation was typical dinner table fare. With that for a childhood, what other course could I have chosen but education?

This work would not exist without the people at Holt High School, especially Larry Burgess and Barbara Neureither, who welcomed me into their classrooms and taught me most of what I know about teaching biology. Thanks of course are also due to the students in my genetics class, spring 1995. I appreciate your putting up with my weird questions, odd comments, and often stumbling pedagogical efforts. You are the core of this work. I hope that I have come somewhere near doing justice to your brilliance, thoughtfulness, intellectual and emotional energy, and creativity.

The Women In Science Education Group (at MSU) has been an ongoing source of support and inspiration for me. Its membership has changed over the years -- and each member has in some way contributed to my life and my thinking. So, to each of you:

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teaching. I am a much better writer, teacher, and human being due to the opportunities I have had to witness his generosity of mind, heart, and soul.

My best friend Stephanie Kay Williams has gifted me with unending faith and forever friendship. Ever since that day in the library of Rochester Adams High, through marriage, childbirth and divorce; desperation and joy; failure and success -- and all those everyday experiences and feelings in between. Thanks for doing your damnedest to keep me physically -- and emotionally! -- fit for these hectic years. Go Michigan scholar! (Now *I'm* going to cry!)

My daughter Emily has been a constant source of support and inspiration, as only a brilliant and beautiful child can be. (You are to beautiful! I know you know you're brilliant.) Thanks for your fresh insights and indignant feminism. Thanks for company during the tearful wee hours. Thanks for putting up with way too much fast food, and too many hours without me. Thanks for baking bagels and cookie bars (those oatmeal chocolate chip things are awesome!) Thanks for making me tapes, and trying to keep me up to date on the good music out there (especially Ani). Thanks for sharing your endless supply of fantasy and mystery novels. You are my best teacher -- my constant reminder that schools would do well to listen to their students. I will try to do better when it comes to listening *to you*! I'm looking forward to many more years of emotional and intellectual companionship.

There is no way that I can possibly construct a thank-you that will do justice to what Bill Rosenthal has done in supporting me through graduate school, through myriad presentations, through the job search, and especially in these last days of dissertation preparation. Only people who know Bill well can come anywhere near comprehending the superhuman feats he has accomplished to help me complete this document. From inception to finish, his endless energy fueled my own sometimes flagging commitment. He pushed me to clarify and strengthen my ideas and my writing. His editorial help was phenomenal

-- substantively as well as in the details. (If there are any imperfections in this manuscript, he is not to blame!)

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For valuing my ideas even when (especially when) I didn't.

For listening to my dreams: the mundane, the monstrous, and the glorious.

For losing sleep because of me.

For feeding me.

For taking me places.

For not leaving when you may have wanted to.

For letting me be myself, again.

For insisting on loving me through it all.

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CHAPTER I

INTRODUCTION AND OVERVIEW

Introduction

Feminist theory has fundamentally altered the way I look at classrooms. As a feminist scholar and teacher researcher in science education, I am eager to utilize the powerful explanatory perspectives created out of this academic work. I am convinced that feminist theory can inform and transform science education, but there is a need for work that brings science education and feminist theory together. In particular, feminist theory is often written in a language that is neither accessible nor inviting to most science educators.

This study focuses on students' images of science as I have recorded and interpreted them. The students with whose ideas I have worked were in a human genetics class that I taught in the spring of 1995. It fulfilled these sophomores' second semester requirement for biology. This course was taught in a high school that served a mostly White, working-class neighborhood. The curriculum for this human genetics class was developed by an experienced genetics teacher; I worked closely with her and utilized many of her teaching plans and her expertise.

I hope that my work will cultivate common ground between feminist scholarship and science education, while deepening our understanding of the rallying call "science for all." I especially hope that this dissertation will open up conversations between science educators and their students around issues concerning students' relationship to science and their clear-eyed views of its current and potential role in our democracy. The exploration of our students', as well as our own, images of science as a social enterprise are central to any effort that claims to make science education welcome to all American students.

Dual Influences: Where Science Education and Feminist Pedagogy Converge

Current thinking in science education demands that science teachers attend to what their students are thinking. An outgrowth of constructivist theories of learning, this requirement for responsible practice in science teaching was one that I learned well in my teacher preparation courses. It succeeded in transforming my thinking about teaching. The very idea that my students' ideas would *shape* what they learned altered my vision of teaching from one in which my responsibility lay in accurately relaying intriguing ideas to one in which my role was to provide learning contexts within which students would create *their own* ideas. I cannot stress enough how much more fascinating, complex and challenging this simple concept of students as knowledge-makers made the work of teaching for me.

A vital piece of teaching based in constructivist theories of learning is that the teacher continually assess what her students are thinking. The reason for this active monitoring is to provide feedback so that the teacher can structure instruction so that students may better approach the accepted scientific concept under study. I continue to believe that this is a valuable aspect of responsible pedagogy. I can't claim that I ever got terribly good at supporting students in expressing their thinking. I did get better at it, and my conviction of its central importance in instruction grew. *Listening* has therefore become the image and the practice that I am using for the kind of pedagogy I wish to develop and the type of research I employ.

For this dissertation, I have taken a perspective that is slightly askew from that of listening to students in order to support or challenge their thinking about natural phenomena. During my teaching, I set up situations in which students could speak about their images of science; these situations are integral to this study. My research goal was to listen in order to learn what students were thinking and believing -- but not necessarily in order to change that thinking or those beliefs. This tack is aided by the fact that the students' ideas I have chosen to study are not conventionally scientific, nor were they explicitly taught as *content* during the time I worked with these students. I focus on students' visions of science, which are connected to, but distinct from, the explanations of the natural world that I hoped students would learn in biology class.

This leads me to a related feminist demand that we respect our students as whole beings with valuable knowledge and beliefs of their own. This perspective perturbs a knowledge hierarchy placing experts at the top and K-12 students at the bottom. In the traditional, expert-novice structure, knowledge flows one way: from expert to novice. No matter how attentive reformers are to pedagogies that recognize students' ideas as relevant to their learning, this epistemological escalator resists a change in direction. Feminist pedagogy, on the other hand, suggests that teachers and students should work to upset this arrangement, in which teachers (and the scientists they represent) are assumed to have the most, and the most important, knowledge. Respecting what students bring to the classroom in terms of knowledge -- as real knowledge, not as something that needs to be altered or expunged -- is a goal of feminist pedagogy. This is different from the perspective permeating science education that views students' ideas as "misconceptions," or as "naive theories." This doesn't mean that feminist teachers don't want students to learn, which means changing, in some way, their current beliefs and understandings of the world. But it does mean a subtle but powerful shift in focus, from the content to the student.

In this study, I bring together four sets of voices: Those that inform contemporary standards for reform in science education; those that speak from feminist perspectives in education, science, and science education; the voices of students themselves, and my own as teacher and researcher. In tandem, I describe and analyze activities in which students and I engaged with my goal of providing them with contexts in which to speak of their visions of science, and I analyze what it is that students actually said within these contexts. This analysis is greatly inspired and informed by feminist critiques of science.

The Underlying Theoretical Perspective: Feminist Critiques of Western Science

Feminist scholars of the scientific enterprise have developed extensive and potent critiques of the scientific enterprise and the knowledge it creates. A now well-accepted finding of this body of work is that the fact that Western science has been largely developed by Western men of the middle and upper classes, and therefore embodies a set of epistemological rules that reflect the values of this group. For example -- an example that permeates this dissertation -- traditional Western science celebrates something called "objectivity." Objectivity demands the separation of emotion and personal and social perspective from scientific theory development in order to attain the truth about the world. Feminists argue that this vision of objectivity is not possible, and that instead, it is used (most likely unconsciously) as a smoke-screen to *hide* emotional and perspectival aspects of the development of scientific questions, explorations, and theories.

The simple proposition that Western science insists on objectivity for its practitioners provides an interesting puzzle for science teaching. Constructivism argues that students bring existing conceptions about the world to science class. Therefore we must find out what those are. In addition -- partly in fulfillment of this requirement, partly to help them connect science to their own lives -- we attempt, as teachers, to bring in, and support students in bringing in "pieces of the real world." Ironically, here, science teaching departs from the traditional qualities of scientific knowledge, in that it attempts to heal the personality split that Western science claims to have perfected. The puzzle becomes how to welcome students' experiences, feelings, and beliefs -- things that are not welcome into objectivist science -- into a venue that also values their learning to understand the powerful knowledge that scientists have created about the world.

Dissertation Organization

This dissertation is set up to demonstrate the potential harmonies between national standards for science education and feminist approaches to science and pedagogy. Harmonies, of course, do not exist unless at least two voices are sounded at once. As a teacher, I kept feminist ideas and standards-oriented, "science for all" pedagogy in my thoughts concurrently. Usually there was little chance for concordance; usually, in the acrimonious debate that went on in my head, the standards "won out." But I believe there were times when both functioned well at the same time. There were possibilities for the apparently unrelated efforts of standards implementation and feminist pedagogy to function together, and to reinforce and inform each other.

It is these comparatively harmonious times that I have chosen to focus on in this study. The dual influences on my teacher thinking and my researcher thinking are diagrammed in Figure 1, which also indicates the feminist ideas that I have utilized to examine each of these contexts. As indicated in this representation, the influences on my thinking come from three main sources: feminist theory and philosophy, science education reforms, and my own experiences. All of these ideas have taught me to *listen* -- and, particularly, to pay careful attention to what students are saying.

The clear boxes represent the three sets of influences on my teacher-researcher thinking. Each is described in Chapter II (The Literature Review), along with their interactions. The light gray boxes represent the methodology -- one that takes "listening" as its main descriptor. This is explained in Chapter III (Methodology). The representation then traces this "methodology of listening" to the development of the data analysis. The data were collected through a variety of activities designed to support students in describing their images of science, explicitly and implicitly, in class and out. The three data chapters each utilize a particular strand of feminist thought to analyze a particular set of data. These are briefly explained in this chapter under **Overview of Chapters**; they are developed more extensively in each data chapter.

The Standards Documents

The standards documents utilized in this dissertation are:

American Association for the Advancement of Science (1990). Science for All Americans. New York: Oxford University Press.

American Association for the Advancement of Science (1993). Benchmarks for science literacy. New York: Oxford University Press.

National Research Council (1996). National science education standards. Washington, DC: National Academy Press.

These standards provided a relatively clear and concise framework onto which I could attach threads from the rich and complex thicket of theories that feminist scholars of

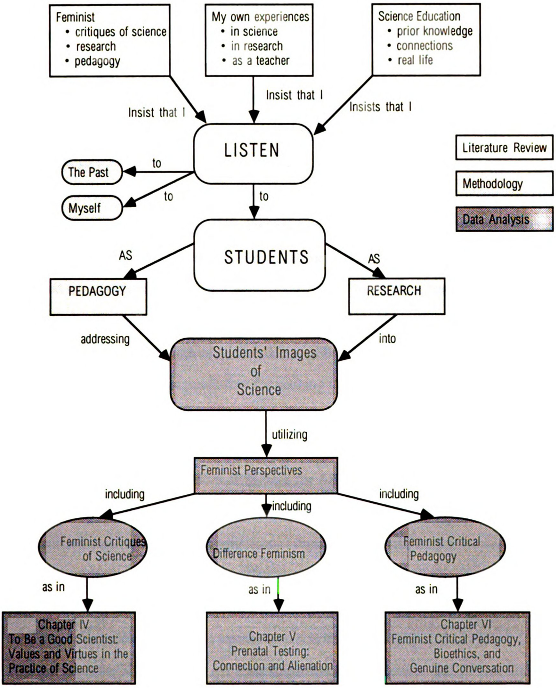

Figure 1 - Graphical Representation of Dissertation

science and of education have produced over the last thirty years. My attitude toward the standards, I should say up front, is not one that looks to them for unquestionable knowledge. As a matter of fact, a fair amount of my time in graduate school has been spent criticizing the silences that the standards contain: Particularly, the silence on radical theories of education and critiques of science, including feminism. I would like to add that, as this research has made me realize, the voices of *students themselves* are noticeably absent from the standards documents.

Nonetheless, there is valuable material set forth in the standards, albeit from a more conservative disciplinary stance than I would favor. I chose the national standards because they represent well the constructivist-based teacher education program from which I received my certification. In some ways, they "work" for me as a teacher. They help me to make content choices. They provide justification for student-centered classrooms, and for curriculum based in depth of exploration over breadth of coverage. In addition, here and there, I find pockets of possibility for pushing these standards to seize hold of the powerful implications of "science for all."

I chose these particular three documents because they represent the call for "science for all" first coined by the authors of Science for All Americans, sponsored by the American Association for the Advancement of Science. This first document efficiently summarizes the science that "all Americans" should know when they leave high school. It also puts forth recommendations for what literate Americans should know concerning what science is, who does it, and what kinds of knowledge it can and cannot lay claim to. In addition, it includes a chapter on current best practice in pedagogy (as of 1990). It is these two last portions of Science for All Americans on which I focus in this dissertation, because it is there that I have found the pockets of possibility for connections between feminism and mainstream science education reform.

The second document is Benchmarks for Science Literacy (1993). These Benchmarks are the child of Science for All Americans. They are sponsored by the same group -- AAAS -- and are based in the same set of philosophical and pedagogical perspectives. They are useful in a different way from Science for All Americans, because they set out in clear statements what students should learn as they progress through school. Along with useful content focus, they also provide concise summaries of what science looks like, what scientists do, and what effect that has on the knowledge they produce.

The National Research Council's 1996 publication of their own set of standards -- the National Science Education Standards -- has added to the resources that teachers can draw on for guidance in both content and pedagogy. As are the AAAS documents, these are based in constructivist theories of learning. They also take a Kuhnian approach to understanding the development of scientific knowledge as being both "conservative" and "revolutionary." And they throw in a few "values" for good measure.

In summary, all three of these documents represent a comparatively progressive attitude toward science education, particularly in their pedagogical recommendations. However, none of them address the powerful implications of feminist scholarship in science or in education. Nor do they question their own assumptions in terms of the role of science in society, which is uniformly portrayed as a positive and progressive force in a democratic society. It is in these places that I believe both feminists and students can inform the standards most powerfully.

Research Questions

To focus my interpretation of students' images of science, I have utilized the following research questions:

• What can intensive listening to students tell us about students' thinking and beliefs concerning their images of science as a social enterprise?

• What aspects of classroom situations encourage and support students' expressions of their beliefs in connection to science?

• How can students' images of science and feminist theories of education and critiques of science inform our efforts toward "science for all"?

Overview of Chapters

This dissertation is made up of seven chapters tied together by their focus on the connections and distinctions between feminist theory and "science for all" national standards recommendations.

Chapters I - III

Chapter I provides an overview of the dissertation and an explanation of the data chapter organization. It also begins the ongoing argument throughout the dissertation based in connections between reform efforts and feminism, but concentrated in students' images of science as a social enterprise.

Chapter II draws from literature in feminist pedagogy to demonstrate how its practice in science teaching is just beginning. It also indicates the relationships and contradictions between feminist implications for science teaching and those set up in the standards documents.

Chapter III describes the methodological issues, contexts, and choices that were made in the course of this research. Traditional qualitative methods in education form the core of the methodology. These are informed by thought in feminist research, as well as the developing field of teacher research.

Organization of Data Chapters: Chapters IV - VI

The data chapters, Chapters IV to VI, consist of analyses of particular classroom assignments that grew out of my feminist convictions. Informed by conceptual change and other constructivist-oriented pedagogies, these assignments were constructed to allow me to hear my students, particularly concerning their ideas about themselves in science and science in society. The analyses do not focus on their immediate instructional efficacy. Rather, they focus on what students said during these contexts.

The organization of the dissertation as a whole (Figure 1) is echoed in the organization of the data chapters (please see Figure 2). Each data chapter is framed with recommendations from the standards and from feminist theory in science and/or education.

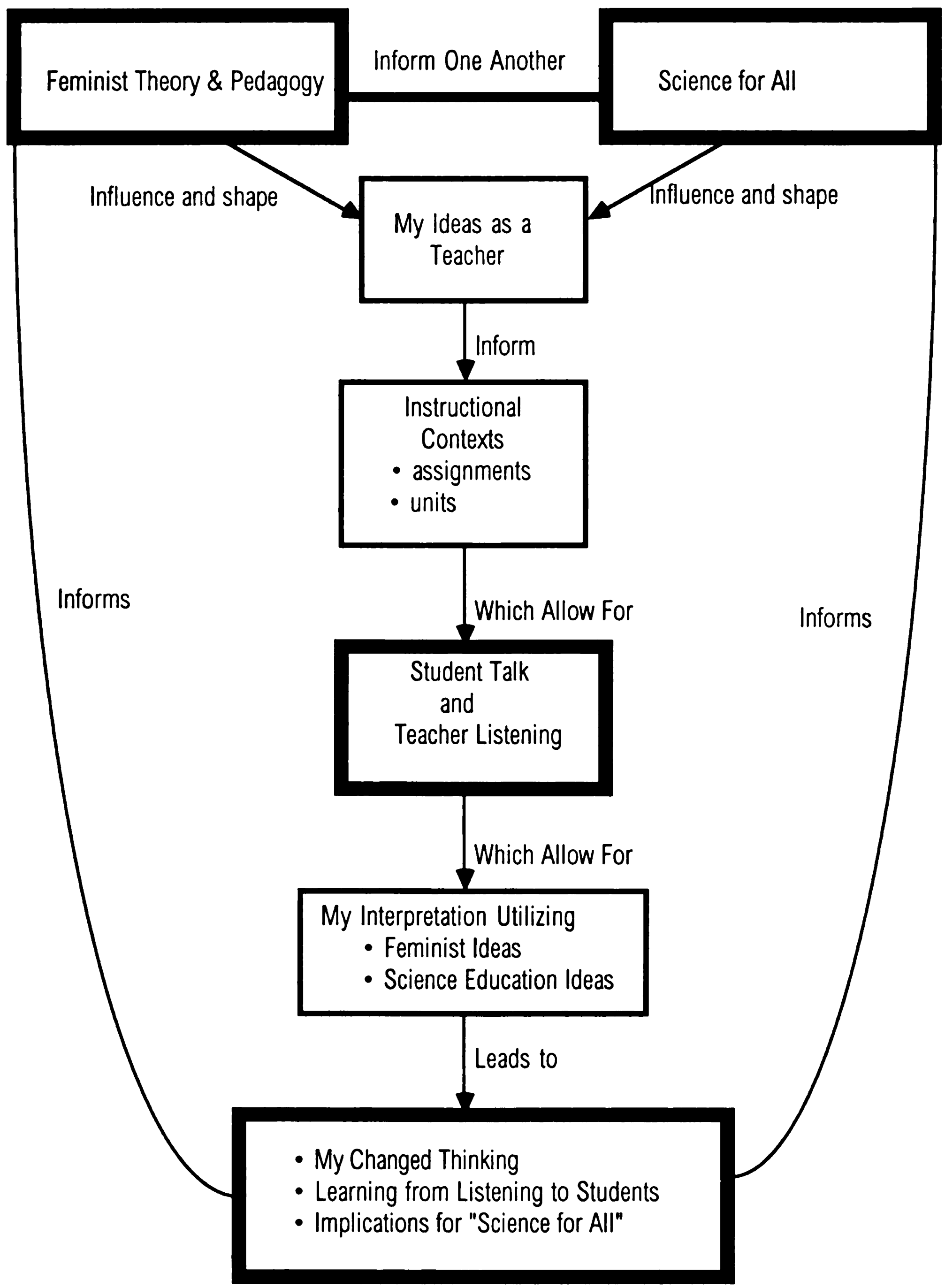

Figure 2 - Structure for Presenting Data Analysis Chapters

I chose these because they represent strong themes in my thinking and practice as a teacher and as a researcher. They were also chosen because they demonstrate the importance of *students'* thinking in improving science teaching. Both from psychological (learning) perspectives and from liberatory perspectives, students' words and beliefs about science and in science are of central import and interest to me.

In each data chapter, I begin by noting a connection between feminist theory and the standards documents' call for "science for all." This connection is developed by text that indicates overlaps and differences between the recommendations as presented in the standards and as interpreted by feminist theory. Following this explication, I explain my teacher thinking in terms of the particular recommendation under study. This is followed by a description of the teacher researcher activity developed out of this thinking. The bulk of each chapter, however, is made up of the analysis of students' words in these contexts.

Chapter IV is titled *To Be a Good Scientist: Values and Virtues in the Practice of Science*. This chapter sets the scene for looking at the data by presenting feminist critiques of science as a social enterprise and the stance that the national science education standards take towards teaching about science as a social enterprise. I then describe these students' views of science as a social enterprise, with a data-inspired focus on "objectivity" and "empathy." Interview-conversations and students' writing in response to questions focused on their views of the practice of science are the main data sources.

Chapter V is titled *Prenatal Testing: Connection and Alienation*. This chapter marks my efforts to apply the problematic and controversial theories of difference feminism to a classroom activity designed to attract girls to science. Here I explore how my female students expressed their relationship to and understanding of prenatal testing and its possible place in their lives and in the lives of others. Tapes of group work, accompanied by student presentations, form the bulk of the data in this chapter.

Chapter VI is titled *Feminist Critical Pedagogy, Bioethics, and Genuine Conversation*. Here I focus on the question: What might whole group classroom discussions that foster students' expressions of their beliefs, experiences, and feelings look like? Chapter VI departs from a focus on students' ideas to discuss the features of a context in which their ideas were welcomed. This chapter is an explication of the concept of *genuine conversation* as I noticed its appearance, disappearance, and variations during a short segment of dialogue on the first day of this bioethics unit. Whole group conversation and discussion form the data for this chapter.

Implications: Chapter VII

Chapter VII is titled *Listening as Pedagogy and Research: Welcoming Uncertainty.* I summarize the issues that have arisen from my in-depth study of students' ideas as they were explained during activities designed to support them in externalizing their beliefs and visions of themselves in relationship to science and of science in relationship to society. My exploration of these relationships (and lack thereof) have resulted in implications for continuing standards development that attempts to carry out its "science for all" rhetoric, beginning by listening to students and other observers, critics, practitioners, and consumers of the scientific enterprise and the knowledge it produces. The feminist claim that Western science demands and has internalized dichotomies between the personal and the political, and the emotional and the rational, is supported by these students' views of science as a social enterprise. These ideas provide hope for healing this split in the science classroom. The concept of *genuine conversation* provides a model for setting up contexts in which the teacher and her students learn to welcome, or at least tolerate, uncertainty as a feature of science classroom life.

CHAPTER II

FEMINIST PEDAGOGY AND HIGH-SCHOOL BIOLOGY

This dissertation grew out of my desire to apply feminist theories of education and of science to my high-school biology teaching. It has developed along a circuitous and sometimes dizzying path between high theory and basic everyday survival in the classroom. Because I was learning to teach (more or less!) at the same time that I was learning feminist theory, my understandings of both pedagogy and feminism developed concurrently. As I wrote this dissertation, this partnership continued.

The focus has changed, however. As do many new teachers, I began with delusions of grandeur that probably did little harm to my students, but certainly were tough on my own self-esteem. To be specific, I was going to change the world through science education: Change students so that they would love and comprehend science for the complex, fascinating, and potent enterprise and knowledge producer it is. Change schools so that they would give students time and respect to develop into conscious and responsible democratic and scientifically literate citizens. Change science education so that it included history, philosophy, and sociology -- and in the forefront of all of these, change science itself so that it would better represent the needs, knowledge, efforts, and dreams of women and others who had historically been excluded from its practice.

My focus shifted from my own visions of power to my students' thinking. As a researcher, encouragement and urging to make this move came from pedagogical recommendations as supported by constructivist theories of learning as well as the politically motivated intentions of feminist and critical pedagogy. In this chapter, I clarify how these two threads in my teacher-researcher thinking continue to guide my analyses of students' visions of science.

Review of Feminist Pedagogy

It is not my goal to provide a definitive description of feminist pedagogy. To do so would misrepresent one of the very tenets of feminism, that is, that there is great variety among women in our racial, cultural, sexual, ethnic, and class identities; our lives, our interests; and our actions. In particular, the teacher who does not critique the discipline, but concentrates on helping young women enter the field as it is, is not necessarily less a feminist than the teacher who openly questions the objective expertise of the scientific discipline. All efforts that attempt to improve the lots of individuals and groups of individuals who have traditionally been blocked from full participation in the practice and understanding of science can fit under this usefully vague umbrella of feminist pedagogy.[1] What I will attempt to do, however, is delineate some common themes that run throughout the literature on feminist pedagogy.

Connections to Mainstream Reform Efforts

Teaching and learning all of the current content of science, let alone keeping track of what ideas, concepts and interpretations are currently in vogue, is a possibility not seriously considered by science educators. Instead, teaching science in ways that demonstrate its intellectual power has been the focus of reformers since at least the Sputnik scare of the 1950s. This emphasis, which runs throughout science reform recommendations, stresses the learning of scientific methods, disciplinary structure (Bruner, 1966; Schwab, 1978), and Deweyan "habits of mind" (1902/1956; AAAS, 1990). None of these plans, however, recommend that students learn that science holds within its very structures the traces of social values, prejudices, and power relationships, both explicitly and implicitly developed and encouraged by scientists[2] throughout history as well as in our own times.

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[1] This is what *I* believe. It does not necessarily reflect the feelings of other feminists, who may insist on a stricter, more bounded view of feminist pedagogy. In addition, many (most?) people who support all of their students in quests for equality and success wouldn't come near the label "feminist" with a ten foot pole.

[2] I am tempted to use the word "science" in places like this, so that negative implications do not taint all who practice science. However, according to Ruth Hubbard, "Scientific language helps to lend science an aura of depersonalized authority. One of its major hazards is reification, the grammatical transformation by which a verb (in other words, something someone does) is turned into a noun, a thing. Indeed the very concept, science, involves a reification because there is no such entity as science. There are only the activities of scientists" (1990, p. 12).

In addition, arguments for reform in science education uncritically celebrate science as the way to technological and economic victory in an increasingly complex and tightly interrelated world society. Understandably, in a venue that needs to accent urgency in order to garner active support, reformers draw on the demonstrated efficacy of science in its ability to productively confront problems of humanity. This tactic supports a stereotype of scientists and their activities that alienates those who are unwilling to wield such super-human power; it also feeds a protective aura around science, denying its political and social contingency.

Portraying scientific knowledge as humanly constructed -- that is, as developed, contested, and consensualized by a social group imbedded in and interactive with the larger society -- can dissolve the mystification that has arisen around science, scientists, and scientific knowledge. A stance that does not take for granted the social isolation of scientific knowledge increases the complications of teaching; yet, paradoxically, its very confusion emphasizes its possibilities. Classrooms themselves are complex places where social life and knowledge production interact (Gore, 1993). A view of science as complex in similar ways illuminates parallels between the science classroom and the scientific community.

Along with a denial of mystification comes the recognition of the political aspects of science. "Political" here is not meant in a pejorative sense (although those who argue for the social neutrality of science would disagree), but as a name for that within science that precludes the desirability, or even possibility, of a view of science that disowns its role in society at large. As is claimed in Science for All Americans, it is important for students to recognize

> the influence of society on the development of science and technology, and the impact of science and technology on society. It is important, for example, for students to become aware that women and minorities have made significant contributions in spite of the barriers put in their way by society; that the roots of science, mathematics, and technology go back to the early Egyptian, Greek, Arabic, and Chinese cultures; and that scientists bring to their work the values and prejudices of the cultures in which they live (AAAS, 1990, p. 189).

It is easy to criticize reform documents for what they leave out; for example, while Science for All Americans argues for the inclusion of "all" in science education, it does not examine how science itself maintains exclusionary practices. The recommendation to teach science as socially contextualized leads one along a path that can go beyond what the writers probably meant -- one that points toward a critique of scientific knowledge and a critical understanding of the scientific enterprise.

In order to move toward this complex goal, one of the many things that we need to attend to is what *students themselves* think about science as a social enterprise. My efforts to teach science in ways that allow students to recognize its socially embedded status have mainly been unsatisfyingly teacher-centered, and intermittent. Most successful and exciting have been those episodes in which I have tried to stay out of the way, supporting students in expressing their own beliefs, feelings, and understandings of science as a social enterprise. Further down the road lie any recommendations concerning what "teachers should" do in order to help students alter these beliefs, feelings, and understandings.

My temporary conclusion, in terms of teaching students about science as a social enterprise, with all of the attendant political, social, and epistemological implications, is that listening to students is a necessary first and continuing step. This is not in order to *change* students' beliefs about science, but to value their images and give them the opportunity to expand their visions. Feminist pedagogy provides a forceful ally in this effort.

Feminist Pedagogy (in General)

As do all pedagogies, feminist pedagogy "implies both instructional practices and social visions" (Gore, 1993, p. 15). Both facets define and create feminist pedagogy; connections between the two form the most intriguing and most problematic opportunities for teaching. Feminism lends itself to such useful vagaries and multiple conceptions, as does teaching itself.

It is one thing to say that knowledge is tentative, created by human beings interacting socially, and thus imbued with fallibility and affect; it is another to say that it (at least, academically respected knowledge) is created by members of a society that has yet to rid itself of class, racial, ethnic, and gender biases and inequities. This statement can be subversive, in that it undermines the very curricular goals with which teachers and students are meant to interact. In addition, demonstration of the social contextuality of knowledge is complex and time consuming -- and, some believe, the purview of women's studies or philosophy, not science.

As I consider my own teaching in light of feminist pedagogy, I realize that what I do in the science classroom may manifest aspects of feminist pedagogy, but is certainly not consistently such, no more than it is consistently social constructivist, conceptual-change oriented, or didactic. Feminist pedagogy itself employs many methods in common with other pedagogies; it did not arise, fully formed, like Venus from the sea. In fact, it is still very much in the process of evolving and unfolding, as more teachers attempt to carry their feminist convictions into the classroom.

Feminist pedagogy falls within a progressive tradition that focuses on students' interests and ideas. In this tradition, the teacher becomes a facilitator and a source of knowledge (but not the only source) and at least partially surrenders and denies her absolute authority over learning in the classroom (Dewey, 1902/1956; Roy & Schen, 1987; Shor & Freire, 1987; Shrewsbury, 1987). Constructivist and conceptual-change pedagogies share with feminist and critical pedagogies a progressivist view of learning in which students are not Locke's *tabulae rasae*, but possessors of knowledge that will influence how they interpret new ideas and how they accept, reject, and alter any curriculum.

As contemporary offshoots of progressivism, critical and feminist pedagogy share the added aspect of listening to students' "lived experiences" (Fine & Macpherson, 1993) -- bringing students' lives into the classroom and, ideally, starting the curriculum in students' questions and concerns. As practiced and popularized by Paulo Freire and Ira Shor

(1987), critical pedagogy takes liberation as its goal, via the recognition of oppressive structures and the development of collective action to change political situations. Feminist pedagogies are different from most critical pedagogies in that they focus on gender oppression and create learning situations and material deriving from women's lives and feminist theorizing.

Women's Studies and Teacher Education: Two Strands of Feminist Pedagogy

There are, as Jennifer Gore (1993) explains, two strands within feminist pedagogy itself. These strands developed, in comparative isolation, within women's studies programs and inside departments and colleges of education. The first strand arose out of the consciousness raising and community education efforts of the 1960s and 1970s (Gore, 1993; Hartsock, 1979). The second has arisen within departments and colleges of education, and so is therefore concerned with connections to other traditions within educational history and theorizing, and with how these traditions can be critiqued, altered, and developed from a feminist perspective. People within education work to develop pedagogies that include and reflect their knowledge of feminist theory, history, and social and intellectual critiques. The second group of pedagogies draw from, and often take as models, those developed in women's studies, yet reflect the stance and expertise of their developers within colleges and departments of education (Gore, 1993).

In feminist and critical pedagogies, the need to situate educational practice in the experiences of the students is stressed. This aspect of teaching from a political perspective argues that content and pedagogical choices (including evaluation) should be, at the least, influenced by the group. However, particularly in science, feminist pedagogy can be conducted even if science content is represented in ways that do not address its social embeddedness. For example, the professor in the first example below (pp. 21-22) alters the traditional structure of the science classroom to include group work, discussion, and long-term projects. In this sense, authoritarian relationships in the classroom are lessened, without challenging the authoritative position of the knowledge to be learned. This separation of process and content leaves out critiques of the discipline, but it may succeed in attracting more women to science.

Making the content a focus is somehow a different sort of problem from one that highlights group process. The challenge shifts from organizing a mutually respectful learning community in which all members support each others' learning, to helping students interpret and create knowledge from a position of informed critique. Of course, the two are connected, but this connection does not always appear in the literature.

Feminist Pedagogy in Science

Why Biology?

The only science in the index of The Feminist Classroom (Maher & Tetreault, 1994) is biology; no chemistry, no physics, no mathematics. This is consistent with the observation that biology has been, for various reasons, accessible to women, and to feminist critique; and is surely an effect of the comparatively large numbers of women in the life sciences (38%) as compared to chemistry (25%), physics (8%), and mathematics (19%) (Finkbeiner, 1994)[3]. While there are multiple feminist critiques by scientists and philosophers of the knowledge and practices of biology (Bleier, 1986; Fausto-Sterling, 1992; Hubbard, 1990; Keller, 1983; Tavris, 1992) there are few in the "harder" sciences of chemistry and physics (Harding, 1991; Keller, 1992). This situation expands into feminist pedagogy; any new work concerning feminist pedagogy in science is greeted with great interest (Barton, 1995; Hazelwood, 1996; Roychoudberry, Tippins, & Nichols, 1993-94). It appears that, as the study and critique of biology have been fertile fields for feminists, so is the teaching of biology the place where feminist pedagogy in science is setting its early roots.

Compared to the other sciences, biology is open to verbal expression, with a smaller stress on more parsimonious symbol systems. Biology is more about our bodies

[3]These figures refer to the number of Ph.D.s awarded to women in the United States in 1989. For a set of statistics that compares degrees in the sciences to those in other fields, see Aisenberg & Harrington (1988, p. 87). For a complex analysis of statistical data about women in science, see Rosser (1992, Chapter 2).

and our world than is obvious in chemistry and physics, and more closely linked to traditional women's work: motherhood, nursing, caring for others, animals, and the Earth. These are reasons that I chose to study biology, and I think that these reasons are connected to the blossoming of feminist critique and possibility in the biological sciences. These facets of biology create spaces in which teachers and theorists can develop curricula utilizing feminist research and perspectives. Biology, with its close connections to human life, welcomes versions of science teaching that include the human and social development of scientific theories.

Feminist Critiques of Science

The extensive scholarship of feminist philosophers and scientists form the epistemological backbone of feminist pedagogy in science. Feminist scientists have developed powerful critiques of scientific theories that have justified the oppression of women in Western society. The much-cited interrelatedness of science and society is clarified and exemplified by feminist critiques; in addition, this work is good science, much of it carried out by practitioners (e.g. Bleier, 1986; Fausto-Sterling, 1992; Keller, 1985). Male scientists have produced theories about women that are based in sexist attitudes: Theories that put women below men in an intellectual hierarchy (Gould, 1981; Fausto-Sterling, 1992); theories that place women's role as sexual temptress and nurturer into a natural primate heritage (Strum, 1987); theories that split the human brain and assign women whichever half is considered less powerful and important at the time (Tavris, 1992).

The ideological promise that underlies objectivity as the best way to find truth has also been debunked in the philosophical community (Grosz, 1993; Harding, 1991; Rorty, 1991). Nonetheless, strangers to science -- and practicing scientists themselves -- often accept the immutability of scientific fact, because it is thought to have been collected and collated by those who have disowned, at least in the practice of their craft, any prejudice or bias coming from their experiences and views of the world. Stuck inside a world-view that sees their own cultural and epistemological norms as "the only way," scientists, as all human beings, regularly fall prey to an inability of to see outside their own perspectives. Feminists have, indeed, argued that "objectivity" is "male subjectivity" (Code, 1993). Feminists assert that the scientific claim of objectivity does not provide its practitioners with a yellow-brick road to the truth. In it place, they are beginning to create a more complex and wholly human epistemology for learning about ourselves and the rest of the world.

The entry of women into science has resulted in critiques revealing the sexist underpinnings of scientific practice and knowledge. As more women enter science, more theories are created and addressed from perspectives that are not exclusively sourced in the male of the species. Women applying the traditional tools of "objectivity" and "logical reasoning" are able to bring science closer to these claims for itself. Thus, whether or not the philosophical and social depths of the enterprise and the knowledge it creates are plumbed, helping more women develop and/or maintain an interest in academic science is itself a feminist project.

One avenue toward this end is to portray science as something that real people do. Doing this in a fashion that refuses to delete emotions, bodies, and social mores may help girls understand what they're getting into, so that we do not have to accuse ourselves of "suckering" them into science, of delivering them to a portion of the patriarchy (Grumet, 1988) that will not necessarily welcome them wholeheartedly. Knowing this, girls may be able to avoid the undermining of self that results from thinking that one is stupid or just not good enough to make it, when the support structures and the expectations (within and without science itself) favor men over women.

<u>College Biology: Two Examples</u>

Frances Maher and Mary Kay Thompson Tetreault (1994) depict two college-level biology teachers who illustrate different possibilities in the feminist science classroom. One of these professors utilizes her understanding of pedagogy to welcome women (and also men new to science) into the world of laboratory practice. In this sense, she is fulfilling several of the recommendations laid out by Rosser (1992, pp. 128-29):

> • Increase the numbers of observations and remain longer in the observational stage of the scientific method. This would provide more hands-on experience with various types of equipment in the laboratory.
> • Use a combination of qualitative and quantitative methods in data gathering.
> • Use more interactive methods, thereby shortening the distance between observer and the object being studied.
> • Use less competitive models to practice science.

In addition, these students developed and carried out their own laboratory studies.

This professor uses techniques that intrigue and satisfy students, often increasing their confidence in their work as scientists. She does not, however, address the underlying issues of the social construction of scientific knowledge:

> [S]he seemed to be saying simply that if women--and their differences--were included in scientific thinking and practice, then science would be expanded and improved. She left untouched the structure of the scientific disciplines and the political and social uses to which they are put, and did not engage the broader views on gender differences (Maher & Tetreault, 1994, p. 138).

While a purist might question whether this kind of teaching, which employs the processes of feminist pedagogy without explicitly addressing gender issues and their part in the construction of science, can *really* be called feminist, what this teacher is doing clearly steps out of the bounds of traditional competitive, fact-focused, large-lecture-hall science teaching. This effort in itself may be subversive, in its refusal to use the do-or-die method of elimination from a rigorous field of study; it certainly appears to be effective in helping students develop a more accurate understanding of the work of scientists.

The other teacher whom Maher and Tetreault profile utilizes her knowledge of feminist philosophies of knowledge to explicitly address the political and societal features of science. Ruth Doell, at San Francisco State University, has created a course, "The Genetic Revolution," in which she works to

> make students authorities with regard to the social implications of science...[considering] "the male dominance of women's reproductive lives, the male dominance of genetic engineering, the construction of science for the well-being of men, with no consideration for the well-being

of society at large, or of women in particular" (Maher &Tetreault, 1994, p. 131).

This professor's language indicates that her course is based in an understanding that places science squarely in an inequitable gender system. She uses this course to help students learn to critique scientific knowledge from this perspective. Ironically, her classroom situation does not reflect the aspect of feminist pedagogy that demands that all students' ideas be treated with respect. In an example described by Maher and Tetreault, Doell supports a female student's argument contradicting that of a male; this is, importantly, because Doell agrees with the woman's comment, and wishes to use it to make a point about the inevitable fallibility of scientists. This situation illustrates a contradiction in feminist pedagogy: Can one respect all ideas and, at the same time, make a stand about one's beliefs (which is itself, according to Weiler (1988), a requirement for the feminist pedagogue)?

Both of these examples point to obvious difficulties in carrying out such activities in the high school. First of all, high school teachers have limited say in the development of the curriculum; no matter how much leeway an individual teacher has, she is still constrained by building, district, and state recommendations. In addition, high-school students are not self-selected for courses and teachers, so the teacher is charged to teach whoever ends up in her classroom. So while "feminist professors must negotiate authority issues in the institution as well as in the classroom" (Maher & Tetreault, 1994, p. 130), high school teachers face these same difficulties, only intensified, in addition to having limited control over content, course organization, and student clientele.

<u>Institutional Constraints</u>

The traditional structure of schools, with classrooms separated by discipline, discourages the overlap of history or sociology and science that would help to create the content necessary for feminist theory to enter the classroom. Furthermore, curriculum, if not mandated by the district or the state, remains within the bounds and the requirements of particular schools and departments. In addition, explicit feminism in the classroom is regularly met with open hostility from students. It is these institutional constraints that are missed by studies in feminist pedagogy at the post-secondary level, where students are self-selected, not compelled to be in certain schools or classrooms, and where teachers may design courses more amenable to a focus on feminist or women's issues.

These objections to easy implementation of any practice from outside the school are familiar. As with any recommendations for reform that do not take into consideration the culture of the high school, they may be discarded as untenable (Sarason, 1982). Thus it is important that feminist teachers within the high school itself develop and critique curricula and pedagogies that fit their particular contexts, while maintaining and utilizing their beliefs and perspectives.

Summary: Feminist Pedagogy and High-School Science Teaching

Based in the knowledge that women have been and continue to be oppressed, feminist pedagogies are openly political. It is this political imperative joined with the centrality of women's lives that distinguishes feminist pedagogies from others. It seems necessary to address the very notion that not only has science been used for maintenance of conservative social structures, but that science itself is imbued with ideology. It is in realizing and analyzing this invisible scaffolding (made invisible by, ironically, a stalwart in the scientific ideology -- objectivity) of the practice, teaching and social justifications for particular scientific research programs that we find the open spaces, the rusty bolts, the possibilities for change.

It is also in these considerations that we can help students explore the otherwise unexamined ramifications of scientific methodology and argumentation. For example, feminists and others have argued that pure objectivity -- the total separation of the knower from the known; the separation of mind from body and emotion; the development of dry, concise language (Hubbard, 1990) -- is artificial, because human beings, male and female, are social-psychological beings, embedded in and created by their home cultures.

As with any pedagogy, content and process are intimately linked. While this is a truism, it is far from a simple one, particularly in a science classroom, where people all along the political spectrum hope to foster inquiry, curiosity, and an acceptance of ambiguity and the tentativeness of our knowledge about the natural world. It follows from this ideal that one would not encourage such "habits of mind" by presenting knowledge in such a way that it is perceived as finished and unquestionable. Rather, we might engage students in thematic inquiry, thus facilitating their growing sophistication in scientific process (Richmond & Striley, 1994). Alternatively, or in parallel, we might construct activities in which students practice scientific reasoning and debate (Eichenger *et al.*, 1991; Rosebery *et al.*, 1990). Both approaches include the communal sense-making that marks generation and alteration of knowledge within the scientific community.

Feminist pedagogy is not alone in its demand for critique of the discourses, practices and knowledge of science. However, feminist critiques of science have indicated that science is not immune from -- indeed, some argue that it is based in (Griffin, 1978; Keller, 1985) -- relationships between male and female that consistently represent the latter as lesser. Thus it feels inauthentic to me, a feminist who is also a teacher, to teach science as if it were devoid of prejudice, and possessed of a special method which cleanses any knowledge collected or created of the stain of human bias. Scientists may attempt to be objective -- and this form of rigorous self-doubt may remain a check against socially irresponsible science -- yet science itself is not inherently objective. It cannot be -- because people do it.

Strands of Feminist Theory Used in Data Analysis

Feminist thought ranges from the Enlightenment-based demand that women be treated as humans (Pollitt, 1995) to radical separatist theories that see no way out of oppression but escape (Daly, 1990). What all feminisms have in common is the centrality of gender, whether biologically or socially defined, as an analytical frame, and egalitarianism as a political goal (Harding, 1987; Lorber, 1994). In my mind, none of these types of feminist thought eclipses any other. They are all always there -- although some come to the fore more clearly in particular situations and analyses.

Feminist theory can serve multiple purposes in science education research. It includes a substantial amount of critical historical, sociological, and epistemological analysis of the Western scientific enterprise and the knowledge it creates (Bleier, 1986; Fausto-Sterling, 1992; Keller, 1985; Schiebinger, 1993). This work overlaps with other feminist disciplinary critiques in its concern with gender's role in knowledge production, and has led to the claim that values and desires are so much a part of being human that they should not be ignored in the creation and evaluation of knowledge claims. Feminist studies have also exposed the institutional and classroom incarnations of sexism in American schooling (Grumet, 1988; Thorne, 1993; Weiler, 1988), and have indicated that girls and boys experience schooling differently (AAUW, 1992; Sadker & Sadker, 1994). The application of these findings and perspectives is currently minimal, but they provide intriguing lenses for exploration of the progressive agenda of "science for all." My analyses bring these varied perspectives to the effort of developing egalitarian science education.

Like other scholars, academics working in feminist research resist labeling ourselves. Names are assigned to feminists by other feminists. In addition, most feminists draw on and practice various strands of feminist (and other) theories and practices; few identify solely with one strand or another. Therefore, I am joining with other authors (Lorber, 1994; Tong, 1989) in developing labels that fit my particular case -- a teacher-researcher study of high-school students' images of science. The descriptions I provide below are thus open to disagreement. For now, I will explain my own labels and visions of feminist strands of thought as they pertain to this dissertation. I briefly address liberal feminism and poststructural feminism here, because while not openly utilized in the data analysis, they inform my thinking. In addition to being described below, feminist critiques of science, difference feminism, and feminist critical pedagogy are specifically addressed in

Chapters IV, V, and VI, in that order. Please see the reference list for publications that illustrate each of these perspectives. I have also included, at the beginning of each chapter, a list of "markers" of the feminist perspective that I am applying in that particular analysis.

Liberal Feminism

Liberal feminists recognize that women have been barred from practicing science because of political and social forces external to science. They would argue, however, that this historical fact does not provide an intrinsic motivation for keeping women out. Fix the political and social forces, and more women would practice science -- the way it is -- successfully, as is indeed demonstrated by the increasing number of women in science (but not in math or physics!) Most of the educational reform efforts in science come from this perspective.

In science education, gender equity is included in national calls for reform that demand scientific literacy for all students (AAAS, 1990, 1993; NRC, 1996). This requirement indicates a *liberal feminist* perspective that leaves epistemological and political issues untouched, yet is potentially potent in its openly egalitarian stance.

I started out from a liberal feminist perspective. As a child, I thought that I really got a pretty good deal being a girl, because I could wear jeans *and* skirts; climb trees *and* do needlework; be a mother *and* a doctor. When I first entered education, it was with the goal of helping more girls like and succeed in science. My learning, both through reading and in discussion with colleagues, and experientially, as a scientist and as a teacher, has led me to a more critical perspective.

Feminist Critiques of Science

Liberal feminists would agree that science has been developed (historically) without the benefit of women's contribution. Feminist critics of science claim that this has made science "masculine," unwelcoming to woman, lacking in certain "feminine" attributes that would widen and improve the practices and effects of science, particularly its social impact. Thus girls and women students are not attracted to science and science is unwelcoming to them. The presence of more women in science might help to both reveal and prevent "bad science" about women and to create a more balanced science (another point with which liberal feminists would agree).

This line of thinking is very powerful when addressed to the dominant Western worldview that has made and been made by scientific thought. Feminist critics of science question its claims to objectivity, calling it, for example, a "chimera" (Longino, 1993, p. 10). The superior ways of knowing that scientists have claimed for themselves are thus undermined. Different ways of knowing are explored by feminist philosophers of science. Among these are Evelyn Fox Keller's "dynamic objectivity," which is "a pursuit of knowledge that makes use of subjective experience" (1985, p. 117). Keller refers to this approach to learning about the natural world as "a kind of love" (p. 117). Put up against the typical scientific rationality that permeates modern Western science, any mention of the word "love" is certain to raise a few eyebrows! But I believe that the implications for science teaching are profound.[4]

A less poetic and possibly more conservative alternative to traditional objectivity is the "strong objectivity" of Sandra Harding (1987). She begins with the unassailable claim that women and non-White middle- and upper-class men have been and continue to be excluded from the practice of science. Coupling this with the observation that there are personal and social forces that affect the choice of scientific questions, determine what gets counted as knowledge, and influence who gets heard and who is silenced, Harding argues that the inclusion of women and those men whom science has made unwelcome would create a wider and more socially relevant science. In addition, the varied perspectives that a wide variety of people would bring to science would *increase* its ability to be "objective." In this effort, she also requires that scientists should to make their biases, desires, and goals known. This would obviate the tendency of scientists to hide their biases behind assumptions of traditional objectivity.

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[4]For more on epistemology and love, please see Rose (1994).

Difference Feminism

Various forms of *difference feminism*, which focuses on the effects of socialization and/or biology on women as intellectual and moral beings, have also made their ways in to education, impacting the way some teachers view their students and construct their pedagogies (Belenky *et al.*, 1986; Gilligan, 1982; Maher & Tetreault, 1994). This strand of feminism argues that girls and women, because they are raised to nurture -- physically, emotionally, and psychologically -- the species' young, demonstrate traits that are peculiar to their gender.[5] Among these traits is described as a sense of connection, mostly to other people. This, in turn, reflects the idea that human relationships are central to girls and women. The term "connection" also turns up in studies of girls' and women's "ways of knowing" (Belenky *et al.*, 1986).

Carol Gilligan's landmark study of women's development and practice of moral judgment (1982) proposed that women utilize an "ethic of care" that is based in relationship. Other researchers have explored the implications of this model with pre-adolescent and adolescent girls (Barbieri, 1995; Gilligan *et al.*, 1990) In this model, women consider particular situations as well as the people involved in making moral choices. This departs from a masculine model that is based in abstract rules of justice applied to all situations equally. Implied in Gilligan's model is a valuing of empathy with others. Thus feminine moral reasoning is based in connection, in maintaining important human relationships, and in considering the particulars of the situation under study. In these aspects, feminine moral and intellectual reasoning have much in common.

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[5]A semantic aside is pertinent at this point. The two words "sex" and "gender" are often used interchangeably. From the viewpoint of feminism -- difference feminism in particular -- it is important to make a distinction between the two. "Gender" indicates a social construction; gender is something that people *learn how to do*. Gender consists in a set of traits, behaviors, and expectations that societies train girls and boys to practice and hold. The words "feminine" and "masculine," in this dissertation, indicate that I am talking about traits that I associate with "gender." "Sex" is the word -- and "male" and "female" the differentiators -- that indicates biological difference between girls and boys, men and women. Sex is indicated by the chromosomal complement of sex chromosomes: males have an X and a Y; females, two Xs. Other than this sex chromosome difference, all humans carry the same types of chromosomes. Due to the sex differences allowed by these different chromosomes, males and females develop different reproductive organs. Women are biologically different from men, in that they can conceive, carry and nutritionally provide for fetuses and infants from their own bodies.

It is very important to recognize the difference between learned behaviors and biologically natural behaviors. The studies utilized in this dissertation come from a perspective that states that gender is socially constructed, and therefore malleable. They do not argue that girls and women behave, learn, or make decisions in "feminine" ways because they are "female." One could picture an argument in which someone says, "So, okay, girls don't like to do science. There are plenty of other things they might do. And plenty of boys to continue on with scientific work. *Vive la difference.*" Aside from purely humanitarian reasons, science is too powerful to deny girls and women participation. Scientists and scientific knowledge have been implicated in maintaining political and social systems that oppress women. The work of scientists is prestigious and well-paying; for this reason alone, women need to gain access. Girls may need to change to engage with science as it is. I also hope to see science change to appreciate and adopt the traits that girls are so good at practicing.

Feminist Critical Pedagogy

Feminist critical pedagogy focuses on the social categories of class and race as well as gender, and notes the role that science plays in oppression and could play in democratization (Barton, 1995; Eisenhart *et al.*, 1996). Issues of power and authority are upset and explicitly addressed, including notions of what valuable knowledge is, who creates it, and who has access to it.

In feminist critical pedagogy, boundaries between students' understandings of the world are joined with new knowledge; students' experiences and feelings are valued and count as "real knowledge." Conversation and discussion are vital pedagogical tools and learning activities, and may lead to communal theory making *plus* action. The explicit politics of this kind of teaching, joined with the desire to change life outside of the classroom, differentiate it from pedagogy based in constructivism, which may adopt many of the same pedagogical strategies.

Feminist critical pedagogy makes certain demands on the teacher that other progressive pedagogies may not. For example, the teacher's role in upsetting authority for knowledge includes upsetting her own authority. The teacher's own expressions of values and experiences can leave her feeling vulnerable and lacking in control; the typical teacher behaviors of guidance toward a particular learning goal are upset. She may, paradoxically, in her efforts to establish an egalitarian relationship between her students and herself, end up alienating students who disagree with her.

These conditions regularly clash with traditional science education, in which scientific knowledge is presented as truth and students are expected to learn it absent its social and political implications or sources. These conditions also clash with business as usual in a high-school classroom, because the feminist critical teacher takes her time, deals with controversial issues, and has unexpected turn-offs and uncertain endpoints. However, I believe that it holds great promise for "science for all." Two main points stand out for me here: 1) the honest valuing of students' experiences, feelings, and beliefs, and 2) the potential for supporting students in recognizing and acting on the fact that science is a socially embedded enterprise with implications for the lives of women. Both of these features of feminist critical pedagogy may help us understand our students better, while helping them learn that "real science" is not the fact-oriented, unquestionable entity that they find in their textbooks.

Poststructural Feminism

Poststructural feminists conceive of gender as continually constructed and never constant, thus amenable to intentional social change (Alcoff, 1988; Elam, 1994). Poststructuralism's main point is that the intellectual "structures" that shape our interpretations are everchanging creations of social and intellectual life. These structures can be constraining in the sense of identity development (in the social sense), as well as determining what we see and do not see as relevant (in politics, in academia, in any critique or understanding of particular situations). These structures are often "dichotomous" -- for example, gender is split into male and female; *Homo Sapiens Sapiens* is split into body and mind; creative work is split into scientific-rational-generalizable and artistic-emotional-particular.

Feminists have used poststructuralist stances to examine theories developed by feminists themselves -- thus attempting to see how and where our own otherwise unexamined viewpoints and desires might color our interpretations of social life. This is not to say that poststructuralism is a way to "get rid of" bias, but that recognizing our positions in the world, and our desires for ourselves and others in the world, may help to keep us honest, and may help to keep our work political.

Scientific thought made simplistic claims that scientific knowledge is free from context, and therefore "true" everywhere; free from prejudice, emotion, personal, and social values; uncoupled from the body, heart and soul -- pure "mind." Deconstruction (among other intellectual efforts, e.g. searching for "bad science") has pretty much debunked the idea that mind-work can be separated from social and personal beliefs (Cherryholmes, 1988). Used very powerfully in science to undermine the epistemological claims that scientists make for their work, and also those that philosophers of science (e.g. Bacon, Popper, Kuhn) have made on their behalf, from the outside, feminist poststructuralist critiques of science have disclosed the ways that social and personal desires certainly do and have affected the knowledge that the scientific enterprise has produced. In addition, this work has opened up the possibilities that science itself could be different, better, more complex and less alienating if it were to recognize its own embeddedness in the human social world.

CHAPTER III

LISTENING AS PEDAGOGY AND RESEARCH

Feminist Teacher Research

Until recently, the intellectual dominance of detached scientific rationality in educational research has quieted the voices of teachers and students alike. The emerging methodologies of teacher research have provided powerful means to speak from and listen to these voices, without giving up the emotional, intellectual, and practical richness that make students' and teachers' work so complex (Ball, in press; Lampert, 1990; Wilson, 1995; Wong, 1995). Feminist research challenges the distancing stance approved by Western scientific objectivity (Keller, 1985; Weiler, 1988). Both streams of work challenge intellectual dichotomies that dominate modern intellectual thought. My methodology draws on each of these efforts, with the goal of recognizing the absence of *student* voices in most educational discourses, and to do my part to remediate that absence.

Practitioners in the domains of feminist research and teacher research are actively questioning traditional research paradigms and experimenting with new ways of conducting and writing research. A willingness to explore and experiment with varied ways of representing experience and creating knowledge is evidenced in this work as people struggle with issues of authenticity, rationality, and objectivity, intellectual authority, and troublesome political implications of the methods and uses of social scientific research. Method, methodology, and epistemology are distinct, but necessarily mutually responsive concepts and activities in these ongoing contemporary discussions. This mutuality is pertinent in the epistemological frame of much qualitative research, and most especially feminist research, because both argue that the researcher's theoretical, political, and social positions play a part in knowledge production.

Feminist Methodology and Epistemology

The connections among method, methodology, and epistemology are organic and cannot be seriously examined in isolation; in fact, the intrinsically active aspects of their uses in qualitative research is misrepresented by this separation. I am choosing to do so, briefly, more to indicate their interdependence than to create any fresh delineation or new definitions. In my terms, *method* refers to the mechanics of data collection: the choices about where the camera and the tape recorder go; development of interview questions; and the decisions (rarely static) concerning subjects of study. Very quickly, when thinking about methods, I start slipping into *methodology*: a much richer territory, inclusive of *method*, and augmented by concerns for what counts as evidence, and identifying and justifying portions of the data to delve into, describe, and discuss. One's methodology shapes one's choice of method. For example, qualitative research demands a long time in the field, accompanied by the collection of a variety of data (interviews, written artifacts, and videotaped social interactions, to name a few of the more commonly utilized forms of data creation in educational research).

Methodology of any type provides a frame for hearing, seeing, and feeling human experience, and thus has implications for the knowledge that the researcher creates about the social world. Methodology is chosen to fit with the *epistemological* demands of the researcher and the researcher's community. Epistemology -- the study of knowledge -- produces and examines bases for validity, authenticity, and usefulness of the researcher's accounts and explanations. One of the most powerful of the contributions that feminists have made to epistemology is the argument that knowledge cannot be value free (Shulman, 1994). This is not to say that individuals hear, see, and feel differently because we are biologically different, but because we are differentially placed in a social structure that gives precedence to some ways of knowing over others. *All* humans are located in a social structure that constructs our desires, interests, and sense of power (actual and perceived) -- including the means and norms for creating new knowledge. Thus feminist epistemology speaks of and to all people -- not just the female ones -- who claim knowing as their business.

> [F]eminist epistemology is neither the specification of a female way of knowing (there is no such thing) nor simply the articulation of female subjectivity which reveals itself to be diverse, contradictory and at least partially discursively constructed through patriarchal oppositions. Feminist epistemology consists rather in attention to epistemological concerns arising out of feminist projects, which prompt reflection on the nature of knowledge and our methods for attaining it (Lennon & Whitford, 1994, p. 13).

Feminist methodologists and epistemologists insist on attending to the observation that method, methodology, and epistemology are intertwined, with tendrils and vines from one organically tied to each of the others. This idea is probably not new to qualitative researchers of any political or epistemological persuasion. What is "new" -- what is *required* -- is the notion that the researcher make her place in this thicket overt and accessible to the reader. Making one's own beliefs about knowledge and its creation through research and writing as explicit as possible is a vital element of feminist methodology (Harding, 1987; Olesen, 1994; Smith, 1987). Valuable knowledge resulting from research -- its creation and uses, particularly -- is defined by those in power, often to re-create, fundamentally unaltered, the very systems that they study (Gould, 1981; Keller, 1985; Schiebinger, 1989, 1993). As a feminist researcher and educator, my goal is to challenge and change, not to replicate. Therefore it is necessary to express my political, social, and theoretical place(s) in the world as clearly as possible.

Feminist methodologists, along with other qualitative writers, have also made the revolutionary claim that emotional and personal aspects of the researcher's work need not (in some case, *should* not) be ignored. Intellectual work and personal, practical experience are not discrete but connected: Theory and knowledge claims are not heaven-sent but based in persons who exist within a social system. Questions and issues that attract one's attention arise from one's place in the world. An anthropologist sees and hears different things from a microbiologist even if they are both hanging out around the Ganges; a parent perceives her or his child differently from how a teacher does. My point is merely that what we know, and what we've experienced, shapes what we note as salient, intriguing, or disturbing. (This take on perception is, of course, a tenet of constructivist theories of learning as well.)

It is here that my, and I would argue anyone else's, methodology lies: in the interaction between the ideas in the head and heart and the rest of the world. In this sense, traditional dichotomies of self are set aside by both feminist and teacher-researcher methodologies. They both refuse to deny the *subject* -- the observer, the participant, the feminist, the teacher -- who plans, collects, and interprets the data. They allow apparently contradictory ways of being and thinking to occupy the same space: feminism and science, emotion and rationality, generalization and particularity, complexity and clarity are attended to, simultaneously; one need not be sacrificed for the sake of the other.

Claiming Feminism as Research Identity

Possibly because I came to science, and then to education, later in my life, after and during experiences of motherhood, housewifehood, and research science, I am intensely aware of my changed visions of the issues and possibilities and responsibilities of science teaching. My experiences and learning in feminism have played a large role in these transformative changes and in the elucidation of my consciousness of the content, purposes, and possibilities of science and schooling. Personal transformation is not easy to track, especially after the fact. I know that I have gone through sea changes via my studies in feminism. I cannot, however, pinpoint when, where or why these transformations transpired. I cannot give any single author, theorist, teacher, or friend total credit; many have contributed to, pushed, and complicated my feminist viewpoints.

The transformation that I referred to above is something that many people who have participated in feminist "consciousness raising," in one form or another, experience:

> Under ideal circumstances, transformation occurs, during which something hidden is revealed about the formerly taken-for-granted aspects of sexual asymmetry. Thus, in this model, previously-hidden phenomena which are apprehended as a contradiction can lead to one or more of the following: an emotional catharsis...; an academic insight and resulting intellectual product; and increased politicization and corresponding activism (Fonow & Cook, 1991, p. 3).

Because it results an understanding of the world that recognizes the gendered structure of society, feminist "consciousness raising" enables learning distinct from typical learning in science. In my case, this understanding has followed me into the science classroom, and into my explorations of students' images of science and their own relationships to it.

Teacher Research as Listening

Teachers are embedded in classrooms. Like no other adults, we are uniquely placed to listen to students on a day-to-day basis. There are, nonetheless, barriers to attentive listening by the teacher. Lessons must be got through. Eager students in the front of the room direct our attention away from those in the back who have "checked out." Public announcements regularly interrupt classroom discussion and even pull students out of the classroom, for softball practice, band rehearsals, or golf tournaments. Even in the best of cases, we usually listen for what we wish to hear, attempting to connect and transform students' ideas to the content at hand; hoping to work with the flow of discussion so that it converges upon a pertinent question or intriguing theory; listening for student ideas that can help us push their science learning forward. In this context, it is difficult to focus on what the students are *really saying*. Let alone take the time to explore their visions of science as a social enterprise.

However, sitting in the back of the room -- while it certainly has advantages over standing in the front, in terms of intellectual sanity and clarity -- would not provide me with the contextualized struggle that I experienced in teaching every day with feminist ideas, some more clearly formed than others, in my head. Indeed, it might tend more to produce a relatively impoverished understanding of what was going on in the classroom. It would also not provide me with the intensive, particular relationships that the teacher develops with her students. It would not get at what was in my head as I taught, at least not in the same way (Ball, in press).

The opportunity to conduct research on students' ideas gave me the reason and the excuse to stop and listen to what students were "really saying." Outside of the classroom, outside of the role of teacher, and a year or more removed from direct responsibility for students' scientific learning, I was able to ignore the pull of curriculum and the interruptions of the school day. I was able to attend to what students were saying in a way that put their ideas at the center (Hazelwood, 1996), instead of the science that I wanted them to learn. The activities that I planned and conducted as these students' teacher provided the material for this study, and that was part of their purpose. I don't want to separate too much, therefore, my role as teacher from my role as researcher, because, in fact, my ideas as a researcher informed my teaching choices even as the teaching was going on, and, as a researcher, my teacher-thinking is always present.

Nonetheless, the factor of time -- of actual hours for studying records of students' ideas, as well as of the absence of school-time pressures -- is one that I can't ignore. I was blessed with the time to listen. The way teaching, scientific knowledge, and the high-school day are currently structured, this time to carefully listen to adolescents feels like a luxury. But as much teacher research, it leads me back to teaching. In this case, it has led me to a strong desire to learn better how to listen to students *in the moment*. And, in a larger sense, to work to restructure schooling and science teaching so that students and their ideas are truly at the center.

Method: Means of Collecting Data

"A research method is a technique for (or way of proceeding in) gathering evidence." (Harding, 1987, p.2)

The newly emergent field of feminist social science research has much in common with traditional qualitative research methods (Fine, 1993; Fine & Macpherson, 1993; Olesen, 1994; Reinharz, 1992; Stanley & Wise, 1993). The methods of data collection I employed consist of interview-conversations with students, students' written and oral work, classroom observation through audiotape and videotape, and researcher introspection (Eisenhart, 1988) -- methods that have arisen in ethnographic and narrative research in education.

I taught high school biology for four years; during that time, I taught a total of six sections of cell biology, and six sections of human genetics. Out of these sections, I have audiotapes for most class periods for four sections. I also videotaped the two sections that I taught the year of 1994-1995; this year provides the richest data sources because I have videotape and audiotape data (of both whole class and small group interactions), as well as copies of student work from this school year. During group work, the videocamera and audiotape machine were placed to record students on a volunteer basis. I have also kept records of lesson plans; again, the last year's records are the most complete and detailed. This final year, particularly the last semester during which I taught human genetics, provided the focus area for my analysis.

Subject Population

The subject population consists of students enrolled and participating in the genetics course described above. The class started out with nineteen students, one of whom transferred to another section and one of whom transferred to another school. This left us with seventeen students: one African American Girl, thirteen White girls, and three White boys. Their school served a mostly White neighborhood of a variety of socioeconomic classes, mostly working and middle-class families.

The data from this study are from the fourth and last year I taught this course, which was one of four choices that students had after a semester-long course in biology. The class population was heterogeneous in terms of past academic success. Students participated in this study on a volunteer basis, with parent or guardian permission.

Data Sources

The classroom assignments I used as data sources are journal writing, group work, classroom discussions, and student presentations.

Interview-conversations

Interview-conversations were conducted with student participants last semester of my teaching. These interview-conversations were voluntary, as students responded to my requests made to the whole class. I took an intentionally unstructured approach to these interview-conversations, encouraging students to pursue lines of questioning that they found intriguing, while I added gender-related questions and issues to the conversational mix. I employ the term "interview-conversations" rather than "interviews" or "conversations" because of this structure. They were not pure interviews, because they shifted with each student or set of students, and because I also inserted my own ideas and beliefs occasionally. They were not strictly conversational, either, because I did have particular issues that I guided students to talk about. Some of these were one-on-one, with a solitary student and myself. Others were attended by more than one student.

Students' Writing and Drawing

Students wrote, on more than one occasion, in response to questions I developed with the intent of learning something about their images of scientists and scientific work. These questions were also aimed to learn how the students thought of themselves as scientists. I asked these questions at the beginning of the semester, and at the end. I also utilized similar data from the semester before, during which I had asked questions concerning stereotypes of scientists. The only students' writing that I used from this previous semester was that of students who also were in the genetics class that forms the focus of this study. The questions asked in this vein were:

- What do you think it means to "be a good scientist"?
- Do you think that you have the traits of a "good scientist"? Why, why not, some yes, some no?

I asked students to respond to these questions on January 30, early in the semester. I asked them to respond again, on June 1, late in the semester, with the addition of

- Have your ideas (those that you talked about in A and B) changed at all since the beginning of the year or of the semester? Please explain how and why they have or have not changed.

The question asked in the semester before were asked on a biology exam (January 20). This was:

- We spent a few days discussing the concept of stereotypes of scientists, and how scientists we could imagine could be different from these stereotypes. Explain your position on this issue. Approach it however you like -- humor is allowed -- but take it seriously, nonetheless.

Students in this classroom often drew on overheads or on newsprint. This drawing was to accompany presentations, or else to indicate to me their thinking as an addition to or substitution for writing. Drawings were usually made in groups. The drawings also contribute to the data for this study.

Classroom and Group Discussion

Audio and videotapes of group and classroom discussion were utilized for this study. The data addressed come from small group and whole group discussions during the prenatal testing unit, as well as our bioethics work (please see Tables 1, 2, and 3). Occasionally, I have utilized comments that students made to me, or to the whole class, during times outside of these dates. In these cases, I have indicated so within the text.

Table 1 provides an overview of the concepts addressed in this human genetics course as I taught it in the spring of 1995. The units particularly addressed in this dissertation are in boldface type. Table 4 lays forth the data analyzed for this study.

Table 1 - Overview of Semester

Dates	**Content**
January 23 - January 24	Introduction to Human Genetics
January 26 - January 31	Cystic Fibrosis and Mendelian genetics
February 1 - February 4	Mitosis Karyotypes Genes make up chromosomes Chromosomal replication
February 5 - February 7	Meiosis Karyotypes Genes make up chromosomes Chromosomal inheritance
February 7 - February 28	Genotypes and Phenotypes Dominant and Recessive Pedigrees Chromosomal inheritance Inherited human traits
March 1 - March 21	Monohybrid crosses Punnett square Product rule Probability and Deviation Dihybrid Crosses
March 23 - April 11	Population Genetics Hardy-Weinberg
May 1 - May 4	Sex-linked inheritance Lyon hypothesis Blood type inheritance
May 8 - May 10	**Mutations and genetic defects** **Chromosomal mutations** **Prenatal testing**
May 11 - May 17	**Prenatal testing**
May 22 - May 31	**Bioethics**
May 31 - June 11	Applied genetics Molecular genetics

Table 2 - Prenatal Testing Unit Overview

Content	Date	Brief Description
• Chromosomal Mutations • Prenatal Tests	Thursday, May 4	Work on objectives 8-10. Look tests up in text (BSCS).
• Chromosomal Mutations	Friday, May 5	A substitute teacher. Students read stories about teenagers with Klinefelter's and Down's syndromes and answer accompanying questions.
• Chromosomal Mutations • Prenatal Tests	Monday, May 8	Take notes on teacher's lecture. Accompanying discussion.
• Chromosomal Mutations	Tuesday, May 9	Lecture, discussion and classwork on chromosomal mutations.
• Chromosomal Mutations	Thursday, May 11	Finish chromosomal mutations assignment. Begin prenatal testing assignment: Choose prenatal test and begin research.
• Prenatal tests	Friday, May 12	Continue research and prepare for presentations.
• Prenatal Tests • Crossing Over & Chromosome Mapping	Tuesday, May 16	Some discussion of prenatal tests. Introduction to crossing over.
• Prenatal Tests • Crossing Over & Chromosome Mapping	Wednesday, May 17	Last prenatal test presentation. Some discussion of prenatal tests. Practice chromosome mapping. Review for exam.

Table 3 - Bioethics Unit Overview

Content	Date	Brief Description
• Bioethics	Monday, May 22	Survey Hammer Exercise Begin Personal Reference Sheet
• Bioethics	Tuesday, May 23	Life begins when...
• Bioethics • Applied Genetics	Thursday, May 25	Why study bioethics? Case studies Personal Reference Sheet
• Applied Genetics	Friday, May 26	Work on applied genetics objectives
• Applied Genetics	Tuesday, May 30	Applied genetics objectives *60 Minutes* video concerning bioethics Case studies
• Bioethics • Applied Genetics	Wednesday, May 31	Personal Reference Sheet Life begins when... Life ends when... Begin "design a life form."
• Bioethics • Applied Genetics	June 1 - June 12	Work on "design a life form." Present "life forms. Vote for “best life-forms.”

Table 4 - Overview of Data

Interview Conversations	Student Writing	Classroom Discussions & Group Work
Carolyn, March 22	Biology Final Exam "Stereotype of Scientists" question, January 20	Group work, May 11
Alex, May 10 (?)		Group work, May 12
Jonathan, May 17	"Good scientist" questions, January 30	
Ann, May (?)		Class discussion, May 15
Jonathan, Alex, & Ben, May 24	"Good scientist" questions, June 1	Class discussion, May 16
		Class discussion, May 17
Nicole & Belinda, June 1		Class discussion, May 22
		Class discussion, May 23

Methodology: Analysis of Data and Use of Evidence

Feminist researchers distinguish ourselves from most qualitative researchers by "put[ting] the social construction of gender at the center of one's inquiry," while "the methodological task...has become generating and refining more interactive, contextualized methods in the search for pattern and meaning rather than for prediction and control" (Lather, 1991, p. 71). Thus my research originates in a conception of gender as something that permeates and is actualized by human social and intellectual interactions, including those interactions which generate scientific knowledge and create science classrooms. While some researchers speak of feminism as a methodology, others consider it a perspective (Reinharz, 1992, p. 243). The latter matches most accurately my analytical approach. Utilizing a focus on gender, I illustrate interactions between feminist issues and students' beliefs about and learning in science. It is this that, at the intellectual and political core, makes my work feminist.

To clarify: My perspective is feminist, which indicates that I consider gender a social construction and that my theoretical framework places gender at the center of analysis. This does not mean that I am studying girls alone. This might be problematic, if one considered understanding girls to be the only way to address women's success in school science or to achieve greater social equality through the classroom. However, as a teacher, I taught, was concerned about, and studied *both* boys and girls. In addition, "gender" is not something that only females possess. Gender is a social construct created and practiced by all biologically sexed human beings, within a society that names "woman" as the lesser of the dualistic categories of gender.[6] My study aims to note and describe how female and male students alike, and I as well, maintained as well as challenged this dualistic categorization, and specifically, when and how it played a role in students' ideas about science as a social enterprise.

In concert with conventional qualitative research practices (Bogdan & Biklen, 1992; Hammersley & Atkinson, 1983), I listened to and transcribed tapes of classroom discussions and interview-conversations. I also carefully studied students' writing concerning images of scientists, science, and themselves in relation to science. From these, questions and themes developed. Since I began this research study before I was done working with these students, I was able to return to them with questions and themes that I had notes in the data. (Foremost among these are the ideas of objectivity, empathy, and "scientist as smart," all addressed in Chapter IV.)

Description of Transcription Symbols

Indecipherable talk is indicated with elipses inside parentheses: (...).

Deleted talk is indicated by ellipses: ... .

Comments describing action or tone of voice are indicated with brackets: [].

The sources and dates of student talk or writing are indicated after the quotes, inside of brackets.

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[6]See Chapter II for the distinction between "sex" and "gender."

Quotes from classroom talk, interview-conversations, and student writing are set off from the rest of the text by the use of *Avant Garde* font.

Research Questions

• What can intensive listening to students tell us about students' thinking and beliefs concerning their images of science as a social enterprise?

• What kinds of classroom situations encourage and support students' expressions of their lives and beliefs in connection to science?

• How can feminist theories of education and critiques of science inform our efforts for "science for all"?

My classroom was the site of my data collection, the starting point for analysis, and occasionally an experimental workshop. Reflections on my pedagogical choices are therefore a piece of this analysis, yet I do not thoroughly analyze specific pedagogical methods or create models for feminist pedagogy. I do utilize feminist perspectives to delve into classroom scenarios, activities, and interactions with the goal of discovering places where gender was, was not, or could have been a salient factor in creating and understanding classroom practices and students' relationships to them.

Notes on My Experience of Teacher Research

Coming from a biological science background, my entrance into educational research was one fraught with denial. I indignantly refused to believe that people could be understood "scientifically" -- at least, in ways that I, the superior scientist, thought of as scientific. This conviction was soon set aside by a larger one that came upon me like a tidal wave: Science *itself* could not be trusted as methodologically straightforward and therefore a path to truth. Still, I feared that the self-focus of teacher research would be unsettling to my sense of self-esteem and efficacy as a high-school science teacher. I was right here, of course, and I continued to flail about, searching for a "method" and a "focus" that would fit me and still keep me comfortably detached, so that I wouldn't get stuck in a cycle of self-punishing introspection.

My way out of this came gradually, as my method of analysis consisted of transcribing carefully. I thought as I did this; my thinking came particularly from my feminist consciousness, but was also informed by teaching, teacher educator, and standards-based sensibilities and knowledge. As I transcribed, I thought; as I thought, I wrote. I was surprised. I pondered. I puzzled. I checked my ideas against the data, reaching dead-ends, creating insights, and struggling with complications. What else could research possibly be? Utilizing surprise as an analytical tool, I delved into the unexpected as a way to "make the familiar strange." As I got caught up in what the students were saying, it became necessary to clarify my teacher-role in the activities and issues that with which the students were engaging.

The demands of teacher research are sometimes contradictory (Wilson, 1995; Wong, 1995) and hard on one's ego (Heaton, 1994). Sometimes, as a researcher, I berate myself (gently, because I know what it's like to be a teacher) for such lapses as not labeling tapes, not encouraging enough students to participate in interview-conversations, not making copies of the proper written assignments for the segment under study. This occasional scientific sloppiness adds a certain authenticity to this type of teacher research. Teaching itself is not neat and tidy; it can't be squeezed into equations or boxed into charts. And teaching itself is endlessly fascinating; there is no need to create artificial experimental situations in order to conduct artificial research, when the real stuff is in the heads and hearts, and words and actions, of the teachers and students themselves.

One hopes that records of various sorts (in my case, audiotapes, videotapes, and copies of student work) would make an accurate-enough account of happenings and words that transpired during the periods of study. But I had certain immovable constraints on my time and technology; moreover, respect for students and their learning took precedence over my own scholarly success. The parallel with teaching is striking -- one never knows enough about students' learning. One never has enough time.

Most of all, for me, teacher research means listening to what the students say (Paley, 1986), marveling at their fascinating contributions to the world. I cannot say enough about this pedagogical benefit of teacher research. Next time, I will listen more closely in the moment. I won't let constraints of curriculum and restraints of school on the intellect fetter my students' minds. Without the form my inquiry has taken --- one of intent listening -- I am unsure that I would have arrived at this commitment to a "listening pedagogy."

As implied above, this work has been quite a remarkable experience for me. As could anyone whose work is situated in a public school, I could have chosen any of a myriad questions and issues to study. Settling on a question has been a slippery, frustrating, and sometimes impossible chore. I could have chosen "What do students say to each other before the final bell?" I could have chosen "What are the differences in male and female verbal interactions with their teacher?" I could have chosen the infinitely difficult and concomitantly unavoidable "What science did the students learn?" Currently, however, all of these possible choices have converged upon one central question: *What can intensive listening to students tell us about their thinking and beliefs concerning their images of science as a social enterprise?*

This study is an exercise in back and forthness, as the talk and my interpretations shifted between the students and myself; between the activities and the students' engagement with them; between the personal, the scientific, the political, and the pedagogical. My wide focus remains on the elusive in-betweeness of the talk and the knowledge debated and developed as we spoke about heartfelt and politically hot beliefs and questions around medical technology. There is no endpoint to the students' or to my knowledge; no exam; no teacher-determined right answers or democratically developed communal consensus. What there is is wide-ranging but connected talk, students responding to each other's ideas, and long stretches of time where the students have the floor.

Talking is how people communicate; communication is what keeps us together as social beings; as social beings, after Vygotsky, we know that talking is how we *learn*. In schools, ironically, students are only allowed to speak at tightly prescribed and predictable times. Their speech is controlled not only in time, but in content. Teachers demean classtime talk that dares to deviate from the predetermined topic as "bird walks" or "tangential," with comments like, "That's a very interesting question, but what does it have to do with the issue at hand?" Therefore, in terms of vitality, learning and living in schools is in big trouble -- because talking by students is rare, sporadic, and often shut down prematurely.

Lost in the rush of institutionalized learning, both teachers and students are cheated of powerful learning and living together. Unlike them, I feel as though I have, for a time, "escaped the trap," stopped time. Now I can listen; I can listen over and over and over; I can hear them -- although it may be too late, in the practical sense, I hope that it will help others do the same. I want us to pull our adult selves out of a sarcastic and hurtful conception of adolescents as in need of control and socialization; see that they are already socialized; they know how to speak, when given the chance; they want to learn, when given the chance; they are *alive*: not "lumps on a log" or "walking hormones." The only recommendation I am certain of is to stop, breathe and *listen*. This work represents what I found out, when I listened.

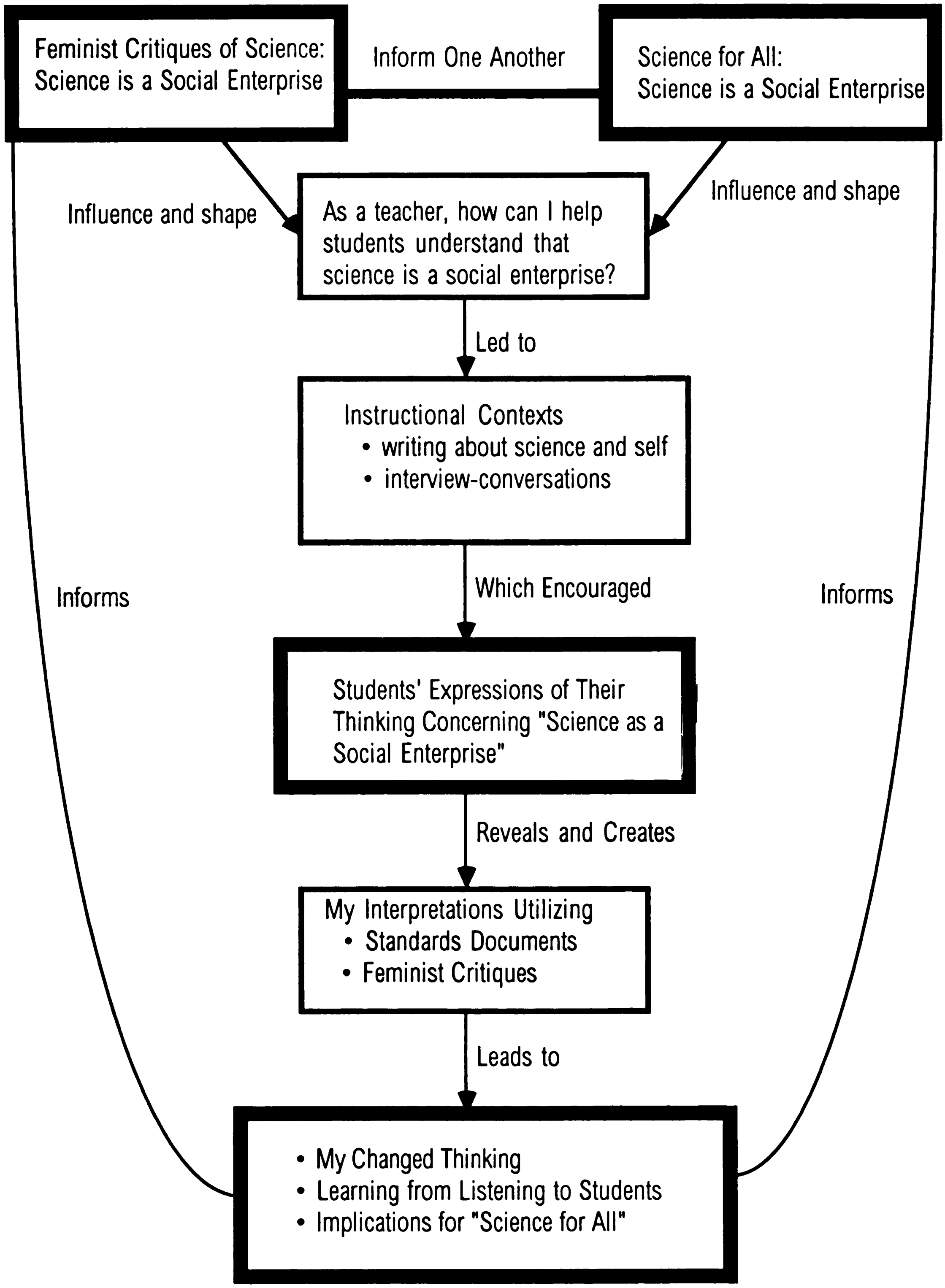

Figure 3 - Flow Chart Chapter IV

FEMINIST PERSPECTIVES & PEDAGOGY

Once contextual considerations of any sort are admitted as relevant to scientific argumentation...values and interests can no longer be excluded a priori as irrelevant or as signs of bad science.
Helen Longino (1990), p. 83.

If we want to integrate feminist politics into our science, we must insist on the political nature and content of scientific work and of the way science is taught and otherwise communicated to the public.
Ruth Hubbard (1989), pp. 128-129.

If the theoretical work [of feminists critiques of science] is to have an impact beyond reinforcing the views of already committed feminists...it must reach the classroom in accessible form....[C]ommitted teachers at all levels must begin to revise their approaches to teaching the science and any other subjects that draw on scientific research.
Mariamne H. Whatley (1986), p. 181.

SCIENCE EDUCATION STANDARDS

[S]cientists bring to their work the values and prejudices of the cultures in which they live.
AAAS (1990), p. 189.

[W]here their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups are about their perceived interests.
AAAS (1993), p. 19.

Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society.
NRC (1996), p. 201.

Markers of Feminist Critiques of Science

• Scientific practice, and therefore the knowledge it produces, is a social enterprise, not an isolated activity or an impartial knowledge-producer. In fact, because people are social creatures, the possibility for an asocial stance is problematic, at the least. Nonetheless, an outdated form of a step-wise "scientific method," informed by value-free "objectivity," continues to hold sway in the public's, in students' and in scientists' imaginations as an accurate representation of science. Science is not objective, in the traditional (i.e. Cartesian or Mertonian) sense that it can provide a value-neutral, "God's-eye view" of the natural world. The form of the final products that scientists put forth often make it appear that way.

• Women and people of races and classes other than White middle and upper classes have been and continue to be excluded from the practice of science.

• Gender, race and class biases make themselves known in the practices and knowledge-production efforts of science.

• The social embededness of science affects choices of questions, what gets counted as knowledge, who gets heard, and who gets silenced. The inclusion of women, and people of races and classes other than White middle- and upper-classes may make these questions wider and more socially relevant, as well as less "partial."

• With "strong objectivity" as their goal, scientists should explicate their perspectives and goals.

• Science should be "for the people."

• Feminists, but not just feminists, have produced a large literature and well-respected scholarship that critiques the traditional practices and epistemologies of science, that provide alternatives for making science better: more objective, in the sense of less partial; more socially responsible, and more epistemologically accessible.

CHAPTER IV

TO BE A GOOD SCIENTIST: VALUES AND VIRTUES IN THE PRACTICE OF SCIENCE

Teaching students that science is a social enterprise is advocated by both mainstream science educators and feminist critics of science. As a teacher, I believed that helping students recognize the implications of the statement "science is a social enterprise" would help them to move beyond stereotypical visions of science and its practitioners as socially isolated, computer-like intelligent, and devoid of the everyday emotions, passions and relational interests of individual and social humanity. I was resolved to address this issue in my teaching, but uncertain as to how to go about it. As a researcher, I was intent on discussing with students the concept that science is a social enterprise; the bulk of this discussion took place during interview-conversations[7] between a self-selected set of students and me. In particular, I was and remain intrigued by the connections, or lack thereof, that students make among science, people, and society. In this chapter, I first set the scene for looking at the data by presenting feminist critiques of science as a social enterprise, and the stance that the national science education standards take towards teaching about science as a social enterprise. I then describe these students' views of science as a social enterprise, with a data-inspired focus on "objectivity" and "empathy."

Feminist Critiques of Science: Science is a Social Enterprise

Feminist scholars of scientific activity observe that the practice of science is a social practice, therefore imbued with human values. Once one recognizes that science is not separate from society, it becomes possible to see that sexism itself has found its way into the practice of science, and the knowledge that it produces. This image of science is difficult to reconcile with traditional science education, which presents knowledge as fixed, its creators distant, dead or nonexistent. The gender, race, and class inequities of the enterprise are hidden behind a facade of objectivity and unquestionable truth.

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[7]Explained in methodology, along with "self-selected group of students."

Feminist studies of science as a social enterprise, and therefore a human construction, illuminate the ways that scientists' work and knowledge interact with their social, political and personal environments (Bleier, 1986; Griffin, 1978; Harding, 1991; Keller, 1985, 1992). Out of these studies has grown the idea that science as purely human disallows what Donna Haraway (1989) calls the "God-trick"-- the ability of thinking from outside of one's social, intellectual, and historical position and heritage. The conception of science as social allows in political, cultural, and personal issues beyond what is typically represented in science courses. It even allows in emotion, connectedness between the scientist and the phenomenon or organism being studied, and responsibility to the Earth and its inhabitants. These are all aspects of being human that are not typically included in traditional representations of science.

Feminist critics of science offer a complex of critiques that continue to develop and evolve. As a scholar, I find feminist critiques of the scientific enterprise convincing and enlightening, backed as they are by the volume of feminist scholarship in science and the complexity and depth of discussion that continue to grow out of them. They help me to understand a combination of emotions and intellectual issues that I have grappled with concerning myself as a scientist, and my own role in the scientific enterprise as a woman, as a scientist and as a teacher. Deviating from the mythology of "pure science," feminist theorists of science concern themselves with the intellectual, social, and personal implications of the scientific enterprise, developing descriptive and explanatory perspectives that powerfully impact my thinking as a teacher.

Contrary to some popular notions of feminist thinking, feminist critics do not generalize or deconstruct science to the extent that it becomes unimportant, uninteresting, to be avoided, or even lacking in beauty and intellectual power. They have and continue to study in depth the claim that “science is a social enterprise”: What effects, positive and negative, does and can this fact have on the practice of science and the knowledge it produces, particularly from a perspective that focuses on gender, but increasingly, also considering race and class (e.g. see Kurth & Smith, 1997)? These studies have led to understandings of why women and others have been excluded from the practice of science. In addition, they are producing the impetus and the power to develop and enact changes in the practice of science, in order make it more inclusionary, more socially responsible, more objective, and more caring.

Feminist Critiques of Objectivity

In everyday life, "objective" means simply the calm, unemotional evaluation of a situation. Science is identified with objectivity, and therefore with a dispassionate, fact-driven interpretation of natural phenomena. As the feminist philosopher of scientific practice Helen Longino phrases it, objectivity "is generally thought to involve the willingness to let our beliefs be determined by 'the facts' or by some impartial and non arbitrary criteria rather than by our wishes as to how things ought to be" (1990, p. 62). The traditional conception of objectivity relies on the disconnection and detachment of the knowing subject from the to-be-known object. A distinguishing aspect of scientific discourse, objectivity can be a positive feature, utilized as an honest striving to avoid prejudice and fantasy. However, an uncritical belief in objectivity relieves the scientific practitioner from considerations of her or his own beliefs and emotions in the development of scientific knowledge. It also allows scientists to skirt issues of ethical choice in research and technological development.

Feminist philosophers of science have also studied objectivity as an effort to delete human emotion from scientific practice. This effort requires and gains support from a differential valuation of women and men in Western society, the same society that has developed Western science. In this split, human traits are assigned to two genders: the feminine is associated with emotion, closeness, passivity and nurturance; the masculine becomes intellect, separation, activity and control. Evelyn Fox Keller's powerful analysis of the development and practice of science, Reflections on Gender and Science (a classic in the feminist literature), explores the implications of this psychosocial dichotomy. She argues that scientific practice and knowledge flow from and reinforce the separation of male from female. In this process, science attributes objectivity to men and subjectivity to women (Keller, 1985). In Keller's words, "The net result is the entrenchment of an objectivist ideology and a correlative devaluation of (female) subjectivity" (1991, p. 283).

A third strand of feminist work with science and objectivity has resulted in a vitally important set of critiques of scientific practice and theory, revealing the sexism inherent in a field that has excluded women from its inception. Male scientists have consistently created theories about women that feminist scholars have successfully shown to be "bad science." In this effort, feminists have broken through the patina of traditional objectivity -- that is, the exclusion of emotion and prejudice from the development of scientific science -- to demonstrate that scientists have and continue to develop theories unquestionably skewed by prevalent preconceptions of women (Bleier, 1986; Fausto-Sterling, 1992; Hubbard, 1990; Tavris, 1992).

Feminist Ideas About Empathy

Empathy is not currently valued in the scientific enterprise. Its basis in subjectivity and emotion outlaws it from the separateness and dispassion that are required by traditional scientific practice. Feminists have begun to analyze this situation, and to imagine how empathy might be included as a positive and enriching factor in understanding the world (Griffin, 1995; Keller, 1983). Coupled with a political stance that argues that science and technology are in need of ways to develop knowledge that do not harm or threaten people or the Earth, these ideas are in danger of being discarded by others as "irrational." The feminist response is that the split between rationality and emotion is not the only way, or even the best way, to understand the world; that while this split has resulted in knowledge that is useful to humanity, it has also resulted in knowledge and practices that are dangerous, deadly, and sick; and that opening science up to alternate ways of learning about the world would not only enliven science, but attract women and minorities to science.

While traditional objectivity treats emotion and connection (i.e. empathy) as impediments, feminists argue that the recognition and utilization of emotion and connection can create an epistemology that engages the whole person-scientist more honestly and fully. Keller names this epistemic revisioning "dynamic objectivity," which she describes as

> a pursuit of knowledge that makes use of subjective experience...in the interests of a more effective objectivity. Premised on continuity, it recognizes difference between self and other as an opportunity for a deeper and more articulated kinship....[T]he scientist employs a form of attention to the natural world that is like one's ideal attention to the human world: it is a form of love (1985, p. 117).

A challenge for feminist science is to honor empathy, along with other traditionally "feminine" values and virtues, while simultaneously maintaining that women are "just as good as men" in other ways, including the ability to apply logic and analytical thought to complex and mysterious natural phenomena. We need to keep from identifying empathy solely with the "female," or we will succeed only in reinforcing the very dichotomies that keep women and men, and the traits they are associated with, separate and differentially valued. Science and empathy as a form of love, in the same breath, creates intriguing possibilities for revisioning science education. It is also a concept that might make science and science classrooms more welcoming places for students who sense the traditional objectivity of science as alienating, inhuman, and uncaring.

Science Education: Science is a Social Enterprise

Authors who do not identify themselves as feminist have also addressed the concept of science as a social enterprise (Bronowski, 1956; Gould, 1981; Kelly, Carlsen, & Cunningham, in press; Lewontin, 1991). In fact, national standards and benchmarks for science education include these (nonfeminist) observations as an integral piece of their recommendations concerning the nature of science (AAAS, 1990, 1993; NRC, 1996). Mainstream science educators recommend that students learn that the practices of science and the knowledge its practitioners create are embedded in a social context. Generally, as represented in the "science for all" standards documents , the logic runs like this:

1. People do science.

2. People are social beings.

3. Science is a social enterprise.

4. Scientists' work and thought, and the knowledge they produce, are therefore influenced by social values and social pressures.

Up to this point, feminist science and the science education recommendations run parallel. After it, however, the recommendations in the standards documents trail off and become less helpful. For example, the authors of Science for All Americans (1990) state, "Before the twentieth century, and well into it, women and blacks were essentially excluded from most of science by restrictions on their education and employment opportunities; the remarkable few who overcame those obstacles were even then likely to have their work belittled by the science establishment" (AAAS, 1990, p. 9). Here is a simplistic attitude, one that implies that it is only the social forces *outside of* science that have kept "women and blacks" from crossing its borders. It also assumes that the "belittling" of the work of women and racial minorities in science is a thing of the past.

Feminists argue that neither of these claims is complete. Science *itself* is a part of this society and this history that have kept women and others out of the scientific enterprise; the very knowledge that science has created, especially in human biology and psychology, has played and continues to play a role in keeping women and others outside of the scientific enterprise. In fact, the development of scientific practice by White middle- and upper-middle-class European males has led to a set of "values and virtues" (AAAS, 1990, pp. 172-175, 1993, pp. 284-287; NRC, 1996, pp. 200-201) defining science -- a set of values and virtues that are not comfortable for all, and while very effective in generating knowledge about the world, may not be in the Earth's or humanity's best interest.

However, there exist vital connections between contemporary mainstream science education and feminist thought. Most pertinently here, scientists as members of intellectual, social, and personal humanity are not left out of the standards' representations of science. Scientists are celebrated as curious, clever, observant, persistent, and sometimes even revolutionary. They buck dogma; they develop whole new ways of viewing the world; they create exciting and intriguing descriptions and theories about how the natural world works. But still -- even these aspects of science tend to get left out of science teaching; and, as I hope to describe in this chapter, these aspects are not only not enough, they are not the only ones that people use to do science. They are emphasized, however, particularly in policy documents, science classrooms, and popular representations of science.

Science education recommendations in general stress the importance of learning what students bring to the study of natural phenomena. If we intend to take the standards seriously and teach about the actual practices of science, it is no less important to explore students' ideas concerning science as a social enterprise. The National Research Council mentions students' views of science as a social enterprise:

> Many high-school students hold the view that science should inform society about various issues and society should set policy about what research is important. In general, students have rather simple and naive ideas about the interactions between science and society (NRC, 1996, p. 197).

This statement falls short of explicitly describing how scientifically literate people should envision scientists' responsibilities to society. Nor does it expand on the concept that society should have something to say concerning the creation of knowledge through the scientific enterprise, or, alternatively, keep its hands off in the interests of intellectual freedom. In addition, this quote indicates a lack of appreciation for the sophistication and clarity of adolescents' thinking concerning the role of science in society, as well as the interactions between intellectual and personal values and virtues and the practice of science. I hope that this chapter will begin to enlarge our views of students' ideas and beliefs concerning science as a social enterprise, as well as teaching us more about how we can teach them concerning this powerful concept.

My Thinking as a Teacher

As a science teacher, I am convinced that the requirement that we teach students that science is a social enterprise should be a vital, central strand of my pedagogy. During the semester that I worked with these students, I wanted them to recognize that prejudice, bias, and power are deeply implicated in the creation and uses of scientific knowledge. I also wanted them to understand that science could be used for more democratically progressive programs. Nevertheless, I remain puzzled as to how to address these issues with my students. This is not an easy admission to make. One would think, of all things, this is what I would be best at, and most eager to teach. After all, it was a goal with which I entered science teaching, and one that has been strengthened and enriched, and has attained passionate urgency, from my studies in feminist critiques of science. Yet I shied away. Why?

The feminist project of demystifying science by placing it squarely within a real society peopled by actual human beings who possess a set of cultural values is intellectually, socially, and politically important. It has also been, for me, profoundly disillusioning. It took some time and some work between the time I encountered feminist (and other) critiques of science to work my way back to a love of scientific knowledge and a revisioning of my relationship with science as it is and science as it might be. How might these critiques affect my students, who were not nearly as committed as I to a life interacting with the scientific enterprise? Would I succeed in helping my students become disillusioned with science, but fail to have the time to help them work through their disillusionment to arrive at an appreciation for the practice of science with all its complexities?

As a teacher, how could I help students learn that science is a social enterprise, particularly within the press of content and the constraints of the public school chronology? I could just tell them, of course -- but both constructivist theories of learning, and a little experience, told my knowledge and my instincts that that would not do. And it would not work, no more that purely didactic teaching about traditionally conceived subject matter would work. Maybe it was so difficult just because it was so important. I was aware that, on a practical daily basis, the transformative ideas imbedded in the simple statement "science is a social enterprise" threatened to swallow up the tender and contentious community that made up our science classroom. I struggled to find a foothold.

As a researcher, I have returned to these ideas. I have checked with the standards, which have often provided me with guidance in choosing and focusing on what *traditional* science content to teach. However, they lack the deep critique of science that feminists and others -- many of them scientists themselves -- have created over the last fifty years. The standards' image of science as demanding curiosity, integrity, skepticism, independent thought, open-mindedness, collegiality, and creativity from its practitioners is surely more attractive than one that describes science as cold, antisocial and step-driven. Science is portrayed as progressive and good for society; the values its practitioners -- when behaving themselves -- attend to are clearly admirable and all American. Nonetheless, this set of "values and virtues" tells only part of the story. Left out are the negative human traits that influence the practices of science, such as selfishness, stubbornness, and prejudice. Also ignored are other positive human traits that would enrich and enlarge the scientific world view and the knowledge it produces, such as empathy and a commitment to democratic goals.

As a biologist and a biology teacher who values -- with skepticism, and, I hope, an open mind! -- the knowledge and accomplishments of biological science, feminist critiques of the biological sciences and the knowledge they have produced are particularly valuable to me. As a scientist and as a feminist, feminist critiques of biology are pertinent and their usefulness clear, saturated as they are with stories of "bad science" concerning women, and epistemological analyses that expose the social basis for sexist science. As a biology teacher, it remains pertinent and yet less clear as to "what to do" with this feminist knowledge. In particular, I did not feel that I had the *time* to help students work through disillusionment to an attainment of more accurate and more critical views of science as a social activity, while also addressing traditional and expected content objectives and standards.

I could spend a lifetime puzzling over pedagogical approaches to these issues. Instead, I reminded myself that students have their own ideas about science as a social enterprise. Individually and in interaction with their peers, students construct their own idiosyncratic, fluid versions of what science is and what scientists do -- and, most pertinent here, what they *ought* to do. So, what did these students think and how could I find out? Somewhere in here might see I some stepping stones between students and these transformative ideas, so that none of us need drown in their import or intellectual sophistication? And in the meantime, attend to Vivian Paley's maxim: "We are, all of us, the actors trying to find the meaning of the scenes in which we find ourselves. The scripts are not yet fully written, so we must listen with curiosity and great care to the main characters who are, of course, the children" (Paley, 1986).

"Kidmarks" Explained

The question, What do students think of science and its connections to society?, was continually in my mind. Thus this chapter reflects a set of activities I assigned myself as I assigned them to my students. The data sources are multiple, connected by content but not centered in a single activity. They are drawn from classroom writing, and from interview-conversations, supplemented by pertinent classroom talk.

Many students included in their models of scientific methodology stereotypical visions of scientific practice that the standards hope to change -- for example, that science is fact-driven, atheoretical work performed in isolation. In other ways, the students' set of values and virtues match the standards. For example, they indicate that ideal scientists are open-minded, curious, and honest. As I continued to study the words of these students, I became increasingly convinced that they were *also* describing and discussing aspects of "science as a social enterprise" that are *absent* from the standards. These students were responding to my questions with, and bringing into our interview-conversations, aspects of being human that are not represented in the standards version of science as a social enterprise. I noticed relationships between students' ideas and feminist representations of scientific practice. For example, Sam, Jonathan and Alex problematize objectivity, and Carolyn and Belinda add empathy to other scientific considerations. It is these two ideas -- objectivity and empathy -- that I delve into in this chapter.

The set of values and virtues that these students, as a group, shared with me does not map exactly onto, nor does it totally contradict, either the standards or feminist ideas. They are distinctly students' own. Therefore, I have given them their own name --- "Kidmarks" -- with apologies to Benchmarks, and to fifteen- and sixteen-year-olds who know that they are not "kids." I attempt here to demonstrate my own feminist, constructivist conviction that students' ideas should not be ignored, nor manipulated, nor excised, by either standards developers, feminist critics of science, or their teachers. They should be attended to as seriously as those markers of scientific activity developed by their elders.

The following sections address these Kidmarks, as I have chosen to name them:

- Kidmark A: Science and Intellectual Values
- Kidmark B: Science and Personal Values
- Kidmark C: Science and Social Values

Please see Tables I, II and III for a summary of values and virtues, organized by Kidmark, noted in the standards, noted by feminists, and noted by these students. As implied above, I do not explore each of these values and virtues, but focus on "objectivity" and "empathy" -- both because these two concepts were clearly evident in the data, and because they are issues one encounters very quickly when one addresses the issue of "science as a social enterprise," from a feminist perspective. Objectivity provides the focus for Kidmark A; empathy for Kidmark B. Kidmark C grew out of these students' insistence that science is responsible to society. It is this last Kidmark that provides the most exciting addition to our efforts concerning "science for all."

Table 5 - Kidmark A: Science and Intellectual Values

Standards	Feminists	Kids
Objectivity	Strong objectivity	Objectivity
Freedom from bias	Recognition and explication of bias	Freedom from bias
Curiosity	Politically and socially relevant choice of research questions	Curiosity
Creativity	"Scientific method" critiqued	Step-wise adherence to "scientific method"
Logic	Logic	Logic
Independent thought	Thought is socially contextualized	Ability to develop good hypotheses and experiments
Team work	Strong objectivity.	Scientists sometimes talk with each other
Accurate record-keeping		Accurate record-keeping
Openness	Strong objectivity -- perspectives "up front."	openness
Skepticism	Strong objectivity	Objectivity
Replicability		Replicability
Honesty	Strong objectivity through explication of bias	Honesty
Imagination	Imagination	Imagination
Checking with outsiders	Checking with outsiders - see strong objectivity	Checking with outsiders
Communication	Communication	Communication
Being clever and inventive	"Smartness" is socially defined, changes with time and context, and isn't usually associated with "woman"	Being smart
Concepts and facts		"Having" knowledge
	Connectedness between the subject and the object of study	

Table 6 - Kidmark B: Science and Personal Values

Standards	Feminists	Kids
Hard work	Hard work not enough (especially if you're a woman or non-White)	Hard work
		Patience
	Emotion	Emotion
	Feelings	Feelings
	Caring	Caring
Use of scientific knowledge to make personal decisions	Personal and political intention affect knowledge creation	Self-protection
	Politics	Other-protection (particularly in realm of feelings)
	Empathy Dynamic objectivity	Empathy
	Creating a better world	Creating a better world

Table 7 - Kidmark C: Science and Social Values

Standards	Feminists	Kids
Responsible work with objects of study	Responsible work with and for objects/subjects of study	Responsible work with and for plants, animals, humans and the environment
Teamwork	Teamwork	Teamwork
Use science to protect oneself (e.g. medicine)	Use science to protect oneself? -- doesn't work well if science hasn't been developed with "you" in mind	Use science to protect oneself (e.g. medicine)
	Protect others from science	Use science to protect others (emergency medicine, disaster relief, children)
Use science to make choices (e.g. risk/benefit analyses concerning environment)	Protect the environment from science	Use science to protect the environment **and** protect the environment from science
		Use science to develop cures
		Use science to end world hunger

Kidmark A: Science and Intellectual Values

Kidmark A is based in an interview-conversation that I conducted with the three boy students in our class. In this interview-conversation, the concept of "objectivity" and attendant issues of "hard evidence" provided an organizing theme. This section mentions no girls. The reasons for my choice to focus on these boys are practical, analytical, and theoretical. Practically: Sam, Jonathan and Alex *alone* participated in the interview-conversation that makes up the bulk of analysis in this section; they and I were the only people present, therefore there are no girls' statements or ideas to directly consider. Analytically, it would thus be strained and artificial to include girls' ideas about "objectivity" in this section, because they never explicitly addressed the issue by name, either during this interview-conversation or elsewhere. Theoretically, as a feminist researcher and teacher, I am interested in what the boys say, because they are no less a part of our sexist society than are the girls. But most importantly, I did not want to include girls' words and ideas in this section in a way that would feel like an "add on" rather than an in-depth analysis, because that would demean the very girls' ideas and words that I wished to respect. Their ideas, therefore, are attended to most seriously under Kidmark B. Both girls and boys are represented in Kidmark C.

<u>Sam, Jonathan, and Alex</u>

Sam, Jonathan, and Alex were the only three boys in this genetics class of seventeen students. All of these young men were successful academically, and verbally adept and apparently eager to speak with me, in class and out. Sam and Jonathan were exceptionally talented in science and mathematics. Jonathan participated in Science Olympiad and planned to be a scientist or an engineer; his passion for and comfort with science were evident during both class and interviewing. While Sam was himself very competent in school science, he did not participate in Science Olympiad and did not evince the powerful draw for science that Jonathan portrayed. Both Jonathan and Sam left their high-school campus every Thursday afternoon to attend a calculus course at the nearby university, because they had gone beyond what their high school could offer in mathematics. Because of this, they missed genetics once almost every week; these absences did not adversely affect their grades.

Alex presented himself to me as a young man interested more in "political science" than in the natural sciences. Through interviews and writing, he told me that his interests lay more with what he perceived to be the human side of things. The year that I worked with Alex, he played a starring role in the school musical; he did so again the following year. He also identified very strongly as a Christian, and was open with me and others about his fundamentalist beliefs, which he initially cited as a reason not to be a scientist. Despite his stated lack of interest in science and his belief in the Christian Bible as truth, he was very willing to challenge both his own beliefs, those of his religious colleagues, and those of the scientific enterprise. Particularly during interviews, he advanced sophisticated questions and arguments concerning the social and historical reasons for the choices that people make concerning politics, religion, and science.

One morning, Sam, Alex, and Jonathan participated in a group interview-conversation, in which they and I became engaged in a discussion about issues of objectivity in the practice of science. Jonathan and Alex both conducted hour-long private interview-conversations with me, in addition to this interview-conversation involving Sam, Jonathan, Alex, and myself. The private interview-conversation with Jonathan took place before this group interview-conversation; Alex and I had two interview-conversations, one before this date, and one after. Sam and I spoke together alone, for about ten minutes, before Jonathan and Alex joined us. I did not conduct a separate interview-conversation with Sam. These three students all wrote and spoke about traditional scientific norms as stated in the standards, and those that more critical authors evince.

What is objectivity and is it possible?

I initially became intrigued with these three students due to an early assignment in this genetics course. Via questions I constructed, I had asked students to convey their visions of science practice as well as their perceived ability to practice it, both in the beginning and at the end of the semester (January 30th and June 1). On January 30th, I asked students to respond to:

A. What do you think it means to "be a good scientist"?

B. Do you think that you have the traits of a "good scientist"? Why, why not, some yes, some no?

Sam's, Jonathan's, and Alex's responses to these questions, as asked early in the semester, are presented below. Sam and Jonathan indicate a belief in the power of scientific methodology as traditionally portrayed. They make brief mention of social responsibility and personal value systems. They uncritically support an epistemology which views interpretations of nature as coming ever closer to the truth; Jonathan even sees the truth as "out there"![8] In this sense, they match closely the argument set forth in standards documents that science possesses a set of values and virtues that scientists practice; that scientists view the world as ordered and knowable; and that science is progressive, in the sense that its workers, over time, develop ever closer approximations to accurate representations of the natural world.[9]

Sam: To be a good scientist you must:
-- be analytical
-- be scrupulous
-- take good notes on experiments
-- have fun while working but stay serious
I have the knowledge (99%-ile on PLAN) and the attitude of a good scientist.

[8]Since my time with Jonathan, I have begun to watch the popular television series "The X-Files." I noticed that the producers use "The truth is out there" for a "slogan" during the credits. Since Jonathan put this phrase in quotes, I imagine that's where he found it. Ironically, "The X-Files" concerns paranormal phenomena. And of the two main characters, a woman and a man, the woman is insistent on solving mysteries through science, while the male focuses on explainations beyond the rational.

[9]I have left students' writing in its original grammatical and phonetical form.

> **Jonathan**: To be a good scientist means to seek truth order and answers. Some of us just learn science in school, but a 'good scientist' poses his/her own questions and 'lives' through science. A good scientist questions his/her surroundings and is always looking for a better answer.
> "The Truth is out there!"

Alex also states a well-known assumption concerning scientific practice and epistemology: It is "objective." Alex, however, states that this trait of a good scientist would keep him from practicing responsible science, because he cannot be objective, due to his religious faith.

> **Alex**: A good scientist must...be objective....I don't believe I am cut out to be a 'good' scientist. I am a Christian and don't believe alot of what I here in my science classes. Besides that, I am much more interested in political science & history.

Alex places himself in the same camp with Sam and Jonathan, in identifying a traditional value of science -- objectivity -- but removes himself from science, unlike his male classmates, by recognizing his own inability to be objective, and therefore his inability to practice good science.

Questioning the Human Capacity for Objectivity: Is the "God-trick" Attainable?

During the interview-conversation described above, these three boys and I delved more deeply into the idea of science as objective. We also touched on other values and virtues of good scientists, both those that Sam, Jonathan, and Alex had mentioned in their writing above, and new issues that had come up since this writing, and during this interview-conversation. We began with my question to Sam about "hard evidence." He had written, in the context of our classroom study of X-chromosome inactivation (The Lyon Hypothesis), in response to the question "Why is this called a hypothesis and not a theory?": "Because it is only a guess and there is no hard evidence to support it -- yet." Later, when I asked him for an example of hard evidence, he said that an example would be "a computer printout." I chose to continue this discussion with Sam, who was the first to arrive to the empty classroom where we were meeting; Jonathan arrived shortly thereafter, then Alex.

When I reiterated the question concerning hard evidence to Sam, he stated that "hard evidence is...something readily accepted by the world. It's, can be computer printouts, big big studies, but you said they had those [many studies] for the Lyon hypothesis...I'm starting to doubt what hard evidence really is now. If there is such a thing." A moment later, he continued, "Or if there is such thing as hard evidence, but it's not enough to make a thesis out of a hypothesis. You need more stuff, and frankly I'm not sure what that is." Jonathan entered at this point, and I asked him to tell us what criteria *he* uses to distinguish a hypothesis from a theory. Sam directed us back to the hard evidence issue with: "There's, there's hard evidence in math but I can't find any examples of hard evidence for science. Because math it's either true or it's not, there's a big black, there's a difference between black and white; in science there's a huge gray area."

With these epistemological wonderings, Sam is coming very close to what philosophers of science call the "tentativity" of scientific knowledge (Popper, 1959/1992, 1962/68). This idea is mainstream -- at least among people who write *about* science, including the standards authors, although not necessarily among practicing scientists themselves. As Sam recognizes, as well, science does require evidence -- but "it's not enough." He implicitly regards science as a social enterprise, noting that this problematic "stuff" he's calling "hard evidence" needs to be acceptable to a wide audience or it will not count. Thus he has left behind a naive image of science as practiced by isolated individuals gathering facts, and building theories solely from those facts. He believes that scientific knowledge occupies a "huge gray area" -- it is not *certain*.

Jonathan takes Sam up on these statements, making a stand that science indeed *does* provide "hard evidence." He asks Sam, "Well what about say that water is made up of hydrogen and oxygen." I ask, "Do you have hard evidence of that?" Jonathan responds with, "Well, you can separate it through like electrolysis or whatever, get the two [hydrogen and oxygen]." Sam guides us back to the Lyon hypothesis: "Well, that's true, but with the Lyon hypothesis nobody's actually observed the Xs receding, they've seen evidence of the receded Xs, but -- " Here I believe that Sam is getting at the idea of "indirect evidence," which certainly forms a great deal of the "stuff" that counts as evidence in science. It is also consistent with a representation of scientific knowledge as tentative and changeable.

Alex entered at this point. I asked him if he could remember his response to the question concerning the distinction between a hypothesis and a theory. He recalled having defined a theory as something that "hadn't [been] proven...without a shadow of a doubt." When I asked, "So you would say that theories *are* things that are proven beyond a shadow of a doubt?," he paused, then responded, "No. To have it not [be] a theory and be hard evidence, then it has to be proven, without a shadow of a doubt. I guess." Alex is not making the connection that Sam had between evidence and theory; he appears to be thinking that "evidence" is indeed something that, at least when it's "hard," is what makes something "proven, without a shadow of a doubt." [10] He represents theory in the popular sense, as something that is closer to a guess or supposition than to an explanatory framework.

Following this, Jonathan and Sam continued their discussion about hard evidence, with Jonathan claiming that there was plenty in biology: specifically, molecular genetics, with its "nucleotides," "codons," "anticodons," and "protein sequences." Sam responded to this claim with "well, that's still more like chemistry." When Jonathan said, "I have a hard time seeing how organic things are any more complex than chemicals," Sam challenged him to "explain the biological process of learning." Jonathan had no problem speculating on this issue at length. But I wanted to get Alex back into the conversation, as well as move the conversation back to issues connected with objectivity. So I reminded each boy of his writing in response to the questions (January 30); these I read out loud. In response to his male classmates' writing, Alex said, "I feel so stupid," and "Now I know

[10] Sam and Jonathan enter here, jokingly, with a theory becoming acceptable, or hard evidence, or truth, "After they pay a lot of money" (Sam) and "Yeah, [after] they spend billions of dollars in research" (Jonathan). These comments indicate a comprehension of science as a social enterprise that utilizes vast sums of money.

how Tammy feels." (Tammy is a female classmate who has commented on Jonathan's "smartness" of Jonathan.) He moved as if to leave, which I insisted he not do.

I then asked the whole group, "Why is it important, or possible or whatever to be objective in...biology or physics and not important or possible or whatever to be objective in...other topics?" Alex responded at length, with the following timely example:

> **Alex**: I was watching the news this morning...with the O. J. Simpson trial. The genetic....for the DNA, I mean they knew, kind of, they'd already arrested O. J., so when they took the blood samples they were like looking for his blood, you know. But to be objective, I think, you need to just, I mean, do it like blindly and just look and see, like in that case, if it was his or if it wasn't....It seems like sometimes...if you have this theory, that you, you go looking for the information that would prove your theory and not – it seems like, I don't know. You look for the stuff that would prove your own theory and then kinda like disregard some of the stuff that is kinda, a little wishy-washy?

Sam and Jonathan nodded and said "yeah" as Alex explained his example of deviation from objectivity, in which he connects objectivity to developing the "truth" solely from "the facts." Jonathan continued with commentary on Alex's example:

> **Jonathan:** I think what Alex was saying is a perfect example of where people aren't following the scientific method. I think that if you were to do that truly you would come up with, your theories would come from your research rather than your research forming and fitting to your theories.

Notably, Jonathan's belief about how scientific knowledge is developed is less sophisticated and less contemporary than Sam's. The standards, along with feminists and other philosophers of science since the 1962 publication of Thomas Kuhn's <u>The Structure of Scientific Revolutions</u>, argue that facts are chosen or noticed due to extant theoretical perspectives; evidence, theory, and scientists interact to develop understandings of the world. While Sam is dissatisfied with evidence as the sole requirement for theory acceptance, Jonathan and Alex want preconceived ideas -- such as O. J. Simpson's putative guilt -- to be disregarded so that theories can arise *a posteriori* from observable facts. Jonathan's version of "scientific method" adheres to a traditional school model that puts observation and experiment *before* theory, in the faith that scientific truth is gained through a totally unbiased perspective. Jonathan, it appears, does believe that the "God-trick" is attainable.

These three boys engaged in this discussion concerning objectivity as an exercise in thinking about whether human beings *could* be objective, not as a challenge to the idea that science *should* be objective. Jonathan staunchly holds out for the desirability and possibility of objectivity in science. Failures of "scientific method" and its attendant objectivity happen -- but the "method" itself, aided by the mechanism of peer review, eventually cleans things up. And Jonathan's discussion and writing on this topic, while it appeared to clarify his own thinking, did not change his mind in this regard, as demonstrated in his late semester (June 1) response to questions identical to those I had posed in January, except for the addition of "C":

A. What does it mean to "be a good scientist"?

B. Do you have any of the traits of a "good scientist"? Why, why not, some yes, some no?

C. Have you or your ideas (those that you talked about in A and B) changed at all since the beginning of the year or of the semester? Please explain how and why they have or have not changed.

> **Jonathan:** ...A good scientist is always reluctant to accept ideas which do not base themselves upon "hard evidence" (A concept which seemes very clear to me)....(T)he scientist needs to be objective as he (sic) delves into the unknown. I think that Science is the intrinsic ideology by which most of our questions will someday be reasonably answered....I would have to say that my idea of what a good scientist is has stayed relatively stable over the period of one semester....My concept of science and what the qualities of quality science are, are basic metaphysical beliefs for me. I understand that many of my fellow students don't allow science to play as large of a role in their lives, so they might be more flexible on this sort of issue but I think that my impression of what a good scientist is has been consistant and to think that it has been revolutionized so quickly would be excessively unthinkable.

During my interview-conversation with Jonathan, he told me that he had rejected his Catholic religion's explanation of the world, and found great satisfaction in scientific explanations of questions of interest to him. (The example he used in this interview-conversation was, "If the world is so young, how do you explain dinosaurs?") The above writing makes me suspect that Jonathan has substituted one kind of a religion for another; his use of the word "ideology" strengthens this claim. Jonathan also validates my own instinctual comprehension that it would be a challenge to help students work through disillusionment in one short semester. However, none of the students in this class had the commitment to science that Jonathan so passionately conveys. So was Jonathan a "canary in a coal mine"? Or was he beginning to feel some threat, internal or external, to his almost religious zeal in his chosen worldview and profession? Or was he simply right -- the transformation of the magnitude that it would have required in order for Jonathan to seriously question issues concerning hard evidence and objectivity, things that he considers hallmarks of scientific activity -- would have taken more than the resources of this course allowed?

Sam indicated a more sophisticated understanding of the complexity of scientific epistemology. He has recognized that scientific knowledge occupies a "huge gray area," and is therefore tentative. Nonetheless, Sam appeared to yearn for objectivity, but was skeptical as to its do-ability by mere humans:

> **Sam:** Unfortunately, we're human...all humans are, there's no such thing as a truly objective human (he says resignedly). Humans, whenever they see something, even though they try their hardest not to, they make opinions about something....And they want to prove themselves right, cuz humans don't like being wrong...(S)o they look for stuff to prove their own theory and they disregard anything that um says that their theory's not true; they just sort of...turned a blind eye towards it? Just don't really look at it, just disregard all knowledge of ever having done that stuff to get to that, that proved it wrong.

In June, responding to the questions above, Sam summarized this view. He also identified himself with those who would have trouble being "objective" as he is interpreting objectivity:

> **Sam:** One has to be objective. One must not let one's personal feelings interfere with one's project....Sometimes...I'm not as objective as I'd like to be...I've added objectivity to my list of traits, because of that one Wednesday morning session.

Alex's response to the questions given in June show a very interesting shift in his thinking. Unlike Jonathan, he has chosen not to reject his religious faith for science; if anything, it is the reverse. However, he moved from believing that he was unsuited to science because his religion is of great importance to him to a statement that "the way science is going," it needs more "'moral' people."

> **Alex:** I first didn't think me as a "Christian" boy would make a "good scientist." After going to the Wednesday morning confrences, I realized that the way science is going, more "moral" people have to go into science to make sure what they are doing is in the good of all mankind & the entire world.

It is as though Alex is thinking that religion, as the social home of morality, needs to play a role in keeping science responsible. Ironically, especially in the face of Jonathan's apparent intransigent stand concerning the idea of "hard evidence" and the possibility for "objectivity," Alex matches better with an outlook of skepticism named as a value by the standards authors, and evinced as well in the feminist concept of strong objectivity.

Kidmark A: Summary

Sam, Jonathan and Alex demonstrated beliefs about science as a social enterprise that both mesh and clash with those that the standards affirm. In their attitude toward the usefulness of objectivity in the creation of scientific knowledge, Sam, Jonathan, Alex, and the standards recognized emotions and preconceived ideas as dangers to be avoided in the development of scientific knowledge. All of the boys appeared to believe that objectivity, thus construed, is a valuable aspect of science, and one to be adhered to as closely as possible.

Sam demonstrated that he was beginning to detect that evidence -- of whatever "hardness" -- is not all that it takes to develop scientific knowledge. By interrogating the issue of evidence in scientific knowledge development, he connects with the standards' philosophical stance that choice of evidence is affected by the theoretical perspective that the scientist adopts. He also indicates a developing understanding of the idea that scientific knowledge is tentative. This stance is one adopted by the standards, but not usually attended to in science classrooms. Alex departed from purely epistemological considerations to add "morals" to the virtues and values that should be -- although, in Alex's view, are not -- intrinsic to the social enterprise of science.

The issues that both Alex and Sam bring up concerning problems with objectivity are ones with which feminists also engage. Namely, objectivity is not simple to attain -- because we are human, we are embedded in a social framework that disallows the ability to leave ourselves behind in favor of "the position of no position that provides a view from nowhere" (Longino, 1993, p. 110). In addition, feminists, particularly Sandra Harding, have developed a concept of *strong objectivity*, which states that naming one's own biases, perspectives and desires is required in order to develop a more truly objective stance (Harding, 1993). In this argument, "personal feelings" are unavoidable, and pretending otherwise contributes to an artificial objectivity that is masked with an impossible impartiality. In addition, some feminists question whether a disconnected stance toward the subject of study is one that creates the best and most accurate knowledge about the world. This issue will be addressed in Kidmark B.

Sam, Jonathan, and Alex contribute examples of adolescents' thinking about the requirement that students recognize that science is a social enterprise. Ironically, Jonathan, the most dedicated scientist of the trio, held on to a fact-driven epistemology that the standards aim to disperse. Alex moved his thinking about science to a different place that insists that science concern itself with moral issues. I think that Alex might take issue with the statement from Science for All Americans: "Whether a scientist chooses to work on research of great potential harm to humanity...is considered by many scientists to be a matter of personal ethics, not one of professional ethics" (AAAS, 1990, p. 12).

These students' conversation is complex and open-ended. They have begun to question their own beliefs; they do not (with the possible exception of Jonathan) treat the scientific enterprise nor the people who practice it as sacred and unquestionable entities with no everyday human traits. On the other hand, they communicate to me, as their teacher, that a transformation in one's view of scientific practice and the knowledge it creates is difficult, and not necessarily fun. Particularly for Jonathan, even considering a transformation of this sort is most unattractive, and as he believes, time-consuming, because he loves science "the way it is." And, even though his conception of the way it is is different from that put forth by the standards, and very different from feminist ideas of what science is and what it could be, he is well on his way to being a "good scientist" as he views that creature.

Kidmark B: Science and Personal Values

Empathy: A Virtue Not Valued in the Scientific Enterprise

As the interview-conversations progressed, I pursued my curiosity concerning whether these students believed that women and men were differently suited for science, and/or if they would conduct science differently. As they considered the question "Do men and women do science differently?," issues of emotion and empathy came up as themes in these students' views of the practice of science. The students argued that women would care more -- for themselves or for others -- than would men. This section indicates not only that the girls (and Jonathan) viewed women as being more "feeling" than men, but that they excluded feeling from science, and thus, possibly, are excluding themselves. Sam and Alex did not comment directly on the issue of empathy (or what I am interpreting as empathy) in scientific practice.

Do Men and Women Do Science Differently?

During our interview-conversations, I described imaginary but possible scenarios that I hoped would provide contexts within which students could express their thinking concerning women and men and their practice in science. The scenarios vary, but the organizing theme was that the situation be based in explicitly human action and thought -- e.g. an oil spill putting threatened species at risk; or the use of government money for scientific funding. I constructed the scenarios to fit the flow of the interview as it was progressing in real time with each particular student. Thus I asked Jonathan about manatees; focused on emergency medicine with Belinda, because she had brought it up on her own; and placed questions for Alex and Ann in the issue of public funding for AIDS research. The "endangered species" scenario is one that I repeated -- dolphins with Carolyn; manatees with Jonathan and Belinda; eagles with Ann.

These students provided descriptions of women and men as doing science that were intriguingly different from the sex- and gender-less images implied in the standards. They bring in emotion and caring -- explicitly speaking of the women scientists as being more feeling for their subjects, while the men were more matter of fact. All of the students to whom I put this issue implied that women scientists and men scientists would get the job done, equally well. The idea that women scientists and men scientists would *feel* differently as a part of their work comes through clearly. In general, these students appear to believe that women scientists would feel more *strongly*; while men scientists might feel as well, their feelings would not be as powerful, as immediate, or as directly connected to the situation at hand and the individuals -- human or otherwise -- involved.

I have organized this section along a spectrum of ideas concerning men and women scientists, and ideas that I perceive as decreasingly obvious in their sexism. I begin with a very clear case of sexism, and move through more subtle and problematic, but probably still harmfully gendered attitudes. I end with Carolyn's empathetic woman scientist, which I argue connects to a feminist possibility for envisioning a "wholly human" approach to studying the natural world.

Ann: Sexism Pure and Simple

During my interview-conversation with Ann, I struggled to find a context within which to discuss the possible existence of a gender-connected variety of approaches to science. First I asked her to consider a situation in which eagles (her choice) were in danger of losing their nesting grounds. Then I tried to take our conversation to math. And then, as I foundered in my efforts to help her talk about women and men in science, I asked her if she had any brothers.

Ann made it very clear that her brother would believe that, as a scientist, "a man would be better." His view contradicts her own belief that "nowadays men and women are equal." Still, we failed to get beyond this clear-cut, black and white idea that men and women are equal -- or, they're not! Ann represents her older brother's beliefs as based in his own failings; one certainly cannot argue with an "idiot."

Elaine: I have this question on here, "Do you think that being a man or a woman has anything to do with being or not being a scientist?" So, if you go back to that story about saving eagles (the "scenario"): (D)o you think a man scientist or a woman scientist would...go about that any differently?
Ann: I don't know, cuz they both can be equal. They, nowadays men and women are equal. Some people it's hard for them to learn more and faster; some people learn very quickly, it all depends on how the person learns. So it doesn't really matter if it's a man or a woman.
Elaine: Okay, what if you think about, um, let's take a different problem...Say there's some important math problem that needs to be solved to build a bridge....Do you think a man or a woman would solve those any differently? And when I say differently, I don't mean better or worse or anything, just--can you think of--
Ann: Oh, I don't know.
Elaine: Like do you have a brother?
Ann: Yeah.
Elaine: Do you and he do anything differently? Or think differently about...
Ann: Oh yeah. Oh yeah. He's a sexist and --
Elaine: (laughter) Oh he is, huh?
Ann: -- and thinks women are stupid, and I'm like "You're stupid."
Elaine: What do you do about that if he says something like that?
Ann: I just think to myself "What an idiot!"
Elaine: Do you say anything to him?
Ann: Ah, I just tell him to "shut-up" and say "you're bogue," and he's bogue.
Elaine: How old is he?
Ann: He's, I think thirty-two.
Elaine: Oh!
Ann: He's old.
Elaine: Ah. I wonder what we could do to help educate him.
Ann: Probably not do much.
Elaine: He's pretty much stuck?
Ann: Yeah.
Elaine: Do you think that he might say that a man scientist and a woman scientist might do things differently?
Ann:: He'd say that a man would be better.
Elaine: And what reasons would he give for them being better?
Ann: Cuz he's a man.
Elaine: That's it? He'd just stop there?
Ann: Yeah.

While lacking in depth and complexity, this vision of women and men as scientists permeates our society, almost unconsciously. And surely it influences women in selecting themselves out of science: Why even try if I'm not smart enough? Unlike Jonathan and Sam, by saying, "I am not smart enough," some girls took themselves out of the running for "good scientist" with one fell blow. For example, both Carolyn and Tammy associate "smartness" with being a scientist; while informing me that they are not smart or knowledgeable, they clearly represent themselves as intellectually unsuited for science. It is obvious that these girls associate "science" with "smart," but they do not associate themselves with "smart" or with "science."

> **Carolyn:** I think that (being a good scientist) means you think well also you make good hypothesis's and you know the whole periodic table of elements...I don't think I have the traits of a good scientist because for one I am not smart, for 2 I don't make good hypothesis and 3 couldn't being to tell you all of the periodic table.

> **Tammy**: I think being a good scientist means that you know what you're doing and you use the problem-solving method....They also have to be smart. I don't have any traits of a 'good scientist'.

Jennifer is more specific, and qualifies her lack of "smartness" as associated with "that subject" (science). Belinda qualifies her own smartness and competence, but still is doubtful of her ability to "have a clue" in science.

> **Jennifer:** To be a good (scientist) means that you can figure out formulas and make some kind of treatment for a viruse or diseases...I'm not smart in that subject.

> **Belinda**: To know what you are doing, what's going on...Sometimes I really get into some scientific stuff and I really know what I am talking about. But then other times I don't have a clue on what's going on.

In addition to these girls' ability to denigrate their own intelligence, the kind of obvious sexism expressed by Ann's brother, so "bogue" that one just wants to ignore it, operates to keep women out of the practice of science. There are men (some of them scientists) like Ann's brother, who think and *say* that women just don't have what it takes to be scientists. However, the clarity of this obvious sexism, on the surface, at least, makes it relatively easy to deal with. Obvious sexism in science is described in the standards -- a place where feminist critique doesn't exactly run rampant -- as women and blacks in historical science are mentioned as "the remarkable few who overcame those obstacles [and] were even then likely to have their work belittled by the science establishment" (AAAS, 1990, p. 9).

For Ann, equality appears to imply sameness, as she indicates in responding to my initial question (see above). The standards, I think, would agree with her here, as would liberal feminism. She puts difference in terms of how people learn. As she herself had been labeled as learning disabled, this could well be a more powerful identifier for Ann at this point in her life than is being a young woman.

Jonathan: Less Obvious Sexism

During my interview-conversation with Jonathan, I described an imaginary scenario in which manatees were directly endangered by an oil spill in the Caribbean. I told him that a man scientist and a woman scientist were in charge of getting the manatees to safety as quickly as possible, and asked him if he thought that these two scientists would approach the problem differently. Jonathan said that he did believe that a woman and a man, at least if they were "randomly chosen," would address the manatee challenge differently.

He then makes what is to me a puzzling connection to his acquaintance with women physicists. This is one place where I see Jonathan being unconsciously sexist or probably even making an effort *not* to be sexist, when he says that the female physicists he knows are "on top of their stuff," as though there might be some question that women physicists would be as competent as their male colleagues. He follows this with a comment that "both genders have the same capabilities" -- something I would consider, indeed, a *non*sexist belief -- and then almost contradicts himself by stating that men "prefer logic more than most females do." From here, it is not a very long step for him to connect logic to science, and men to logic; while the best male and female scientists would "both be excellent," it appears that any old female scientist would not necessarily practice the logical thinking that science requires.

Elaine: I'm...gonna give you a little scenario....Can you think of any... endangered marine species?
Jonathan: Um, how about the manistees?
Elaine: Manatees? Manatee, right?
Jonathan: Yeah.
Elaine: Manistee's a city in (our home state). (Both laugh.)
Jonathan: Right.
Elaine: I get those two confused too. Let's say down in the Caribbean -- isn't that where they hang out?
Jonathan: Yeah, I think so.
Elaine: Well, let's say that there was a big oil spill, and... They come up above (the water's surface), don't they?..
Jonathan: Well, they're pretty close to the, they're pretty close to the surface (*our talk overlapping here*) --
Elaine: Okay, so an oil spill would --
Jonathan: -- because they're, cuz they're always gettin' hit by the props boats and stuff.
Elaine: Yeah, yeah. Poor things.[11] ...So let's say there's this massive oil spill....there's a man and a woman scientist down there. And they're sort of in charge of what's going on. And the idea is to get as many of the manatees out of there, safely, as they can, as quickly as they can....Do you think, that the man and the woman would think of this situation...any differently?...This is not a question...where I am looking for *any* answer. I, I'm not trying to prejudice you in one way or the other, I am just honestly curious about what you think.
Jonathan: (short pause) I think that they would probably think about it differently. Just, if the man and the woman were just randomly chosen. And, I guess, the reason I say that is I've been out to the university and I've met, I've met some physics people out at the university that are female and they're (he laughs) on top of their stuff. And so...I think both genders certainly have the capabilities....It seems to be throughout history, I guess most studies that I've read, that most men tend to think, tend to use, to prefer logic I guess more than most females do....I think that logic would be what -- I value logic a lot and I think that should, should be what's supplied in the case of these manatees. Um, so, and I think that if you were to just draw random (*sic*) throughout the population...I don't think they would both have the same theory of logic thinking about it. But I think that if you were to go through and find the best female scientist in the world and the best male scientist in the world, I think that both of them would be excellent.

At this point, I asked Jonathan to tell me what he meant by "logic." He described a home situation in which both of his parents help him with his handwritten papers -- his mother types them, and makes grammatical corrections. Jonathan quotes her as saying, "We need to put a period here, a comma here, this needs to be capitalized instead of this." His father, in the meantime, reads Jonathan's papers for larger editorial advice, e.g. "This paragraph doesn't go to this one, needs a transitional sentence." Jonathan sums up his example by saying, "My mother tends to look more at how things appear and how they

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[11] I'm being empathic!

come across, how, visually or, emotionally, I guess. Where as the male personalities in my life tend to concentrate more on criteria...meeting specific goals and stuff like that." On hearing Jonathan's story about writing his history papers, I was reminded of a paper my own college-age daughter had written in a history course, in which she had composed a biographical sketch of the Byzantine Empress Theodora from the Empress' point of view. Her professor told her, "This is too personal. I want you to be more objective." Enthusiastically seizing on the word "objective," Jonathan notes it as descriptive of what he was trying to say:

> **Jonathan:** Yeah. *Objective.*
> **Elaine:** Um, when you're writing your history papers --
> **Jonathan:** I tend to value objectiveness more than subjectiveness, I think. So --
> **Elaine:** I gotta let you go...(It's time for him to go to class.)...
> **Jonathan:** That's...a better way to explain it, I guess, that's what I was thinking about.

This interview-conversation occurred before our group interview-conversation with Sam and Alex. On this occasion, therefore, Jonathan is picking up on the word "objective" *before* the more in-depth interview-conversation we had with others. It is not clear where he is headed with this line of thought. *I* had introduced the word "objective"; he certainly seized it as an accurate label for what he was thinking, but he did not come up with it independently. Unfortunately, we ran out of time to pursue the issue at this point. His talk and his writing elsewhere (see Kidmark A) does shed further light on his thinking concerning objectivity.

I fear that the very use of the question, "Would men and women approach this situation differently?" skews students' thinking toward a theoretical framework that encourages them to say, "Yes, they would be different, and this is how." I realize that this question may well have influenced Jonathan's answer, and that it and other leading questions and comments that I made during these interview-conversations could have done the same thing. I hope that by being clear about my desire to understand what students believed that I was able to help them move beyond the "please the teacher" mode enough to tell me what they truly believed. In addition, Jonathan's explanation of *how* men and women would be different as scientists, as well as the following student descriptions, provide a substantial amount of food for thought, whether or not students would have spontaneously distinguished between the work of women and men in science. For example, Jonathan cites "logic" and "objectivity" as important to him and to science. His classmate Belinda describes other, but compatible, values and virtues of the competent scientist.

Ann and Jonathan have already set us on a path that indicates that these students believe that women and men possess different traits. In this, they are following in an age-old tradition that some name "complementarianism" -- the ancient notion that women and men are naturally different and "complementary" in the traits they portray. Thus men are made for war, women for domesticity; men are hunters, women gatherers; men are intellectual, women emotional (Lerner, 1986; Merchant, 1980; Schiebinger, 1989, 1993). It is very difficult to imagine a world in which all of these traits would be truly valued, and therefore men and women truly equal, although different. In addition, feminists argue that this dichotomizing of traits is a construction developed by men (Alcoff, 1988). In this regard, complementarianism has been and continues to be very useful in maintaining the assignment of devalued traits and less-valued work to women.

So I explore this territory carefully, because I do not want to contribute to an intellectual argument that further strengthens the power of separating women from men in "naturalized" ways. But the traits that these girls associate with women represent values and virtues that would benefit science, as well as make science more attractive to women and other people who value traditionally feminine traits as or more strongly than traditionally masculine traits. The most evident of these "feminine traits," in these data, is "empathy."

Belinda: Complementarianism and Empathy

The transcript that follows is drawn from an interview-conversation that began with two students, Nicole and Belinda, who wanted to discuss career possibilities in science with me. Nicole brought to the interview-conversation some printed literature on the profession of "clinical cytogeneticist" that she asked me to help her understand, and to tell her what kind of schooling it would require. Belinda herself had recently rethought her career interests. She had wanted to become an emergency medical technician, but changed her mind due to a pre-prom mock-enactment of automobile crash put on by her school's chapter of Students Against Drunk Driving (SADD).

> **Belinda:** I'm really interested in the medical field, and I wanted to be a paramedic for a while until I started hearing stories and really seeing -- I mean *Rescue 911*, there's not very many deaths on there. And a lot more people die -- I mean, not a whole lot die, but more than what's on there --
> **Nicole:** I watch that show too. And the thought of people dying in my arms doesn't really thrill me, so --
> **Belinda:** And I've heard stories; and the thing that they did, um, last Friday (the SADD enactment) really, it was like, I had sort of changed my mind and wanted to get to a more calm situation where I wouldn't be so emotionally involved and so uptight and stressed out all the time. And I um decided to be a phlebotomist --
> **Elaine:** Oh!
> **Belinda:** -- which is somebody who draws blood...So, I took an interest in that and um, it was just like, when they did that car crash thing, it was like, I don't know if you were there, but they did the *whole*, I mean the cars were already there and the people were in place but the whole thing as if they were really doing it; they came upon that scene. And it was like, I had to choke back tears. I mean, I knew it wasn't real, but it was just like, I could not handle that. It was so emotionally overpowering that it just, I mean, I have so much of an interest to do that kind of thing, but yet I know I couldn't handle it. So I figured, you know, well I want to stay with the medical stuff and still help people so that's why I chose phlebotomy.

Emergency or laboratory medicine, at first glance, may appear too removed from "science" to be a context for discussing scientific values. However, girls tend to make a connection themselves -- when asked how they might use science in their own lives, or the kinds of scientific careers they might pursue, they overwhelmingly cite the health professions (AAUW, 1992; Gornick, 1983/1990; Rosser, 1992). Among the girls in *this* class, Nicole, as already mentioned, turned to me for help with thinking about cytotechnology. So while Belinda is not viewing herself as a laboratory research scientist, she may be thinking of medical technology as a profession that requires the practice of science. In fact, in the following transcript excerpt, Belinda explicitly connects science to emergency medicine.

After Nicole left, Belinda and I continued; I asked her some questions, and provided her with a couple of scenarios in the hope that she would expand on her references to differences between women and men in their approaches to science. I quote Belinda at length because she continually returns to the idea that girls and boys, and the women and men they grown into, approach emergency situations differently. Belinda appears convinced that girls and women would, in all of these situations, be more affected by the *emotional* aspects of these tragedies; while Belinda makes no mention of this emotionality adversely or positively affecting the efficacy of women's choices or treatments in emergency situations, it would take a toll on the individual woman's psychological and emotional well-being.

> **Elaine:** Do you think there's any difference between boys and girls and the way they approach science and think about science, what they like?
> **Belinda:** Yes. I think so. Because going back to what I was saying about being a paramedic or an ET (emergency technician) -- guys are just going to do their job or whatever, and they're not going to think about, I mean it might cross their mind if they come to some gut-wrenching scene or something that's really bad, but they're not going to sit there and think about, "Well, I feel so bad for the family...what can I do to help them?"...They're just there, I think, in general, they do their job, and they don't really think about it, you know, past a couple of days. But I think women tend to mourn -- like, in a sense mourn for the family and feel bad for them. Because, again, they're thinking about well what if it was, what if it was me? You know, stuff like that.

It appears obvious to me that Belinda is describing empathy -- a quality of identifying with others, within a powerfully emotional framework. She is speculating that she would "mourn" for people that she doesn't even know; she cannot resist the summons to put herself in their place. She also distinguishes women from men in this regard, as men would not "really think about it...past a couple of days."

A scientist might say that here Belinda is speaking of accident victims as people one is *caring* for, not people whom one is *studying* from a scientific perspective. So here

Belinda is feeling empathy for "objects of care," not "objects of study." Feminists, I believe, would respond that that is exactly the point: Traditional science separates the two; a revisioned epistemology could include them both, and recognize their interactions as enriching rather than blocking understanding. Belinda's stance in the next excerpt could be interpreted as one that is melding the object of care with the object of study (although that doesn't make the work any easier for Belinda's woman scientist!)

> **Elaine:** ...Let's pretend...that there's an epidemic, like cholera... (Belinda and other sophomores had studied cholera in the fall.) ...You're a woman scientist....You're an expert in disease control, and there's also a man scientist there. How do you think that you and he might go about solving the problem differently...approaching the problem differently, or doing your work...to help these people, to get this epidemic under control?
> **Belinda:** You mean from each other?
> **Elaine:** Yeah.
> **Belinda:** Okay.
> **Elaine:** If at all.
> **Belinda:** Well, I would probably, I don't know....I'm sure on some things we would have, do things differently, because we are two different people but in fact I would probably try not to do things differently? Because...when there's more people you can think of more things to better yourself and the problem or whatever you're dealing with, I think. So...especially when with cholera people dying so quickly that, if somebody thought of something, and you're totally just like not talking to them, and you think of it a month later, and you know and then you come up with, say he came up with a way to cure it but he wasn't sure how exactly to finish the end of his study, and I came up with the whole thing, to where as if he had told me and maybe I could have come up with it sooner. So --
> **Elaine:** So are you sort of saying -- please correct me if I'm wrong here -- that forget about the differences, that maybe the differences are positive --
> **Belinda:** Umhm.
> **Elaine:** -- cuz we can get together and have different ideas
> **Belinda:** Umhm.
> **Elaine:** -- and put those ideas to come up with the best idea.
> **Belinda:** Right.
> **Elaine:** Is that what you were thinking?
> **Belinda:** Umhm.

Belinda implies that difference, *per se*, would have a positive effect on the eventual outcome of emergency "problem solving," but not necessarily because these differences are identified with male and female. It appears to be more that because they are different people, separate individuals, that their combined work might result in a more effective eventual solution to the issue at hand: "Because...when there's more people you can think of more things...and the problem or whatever you're dealing with."

Belinda here is demonstrating an understanding of the standards' and progressive science education's stance that scientists communicate regularly -- that open sharing of ideas leads to better science. Belinda is like Sam in her recognition that scientists work together -- at least when they're working at their best, and most responsible. In this case, the responsibility is to others. This scenario that I provided, where people are dying very quickly and any selfishness on the scientists' part would be unconscionable, may well have influenced Belinda's interpretation of their work.

However, when given a story more closely related to the one that I asked Jonathan to speculate about -- the manatees endangered by an the oil spill -- Belinda reverts again to a conviction that men and women are different. By connecting to "scientific studies" to support her ideas of the differences between men and women, Belinda is also showing an analytical stance similar to Jonathan's.

> **Elaine:** How do you think each of (the woman scientist and the male scientist) might go about, what would each of them think about, when they were solving this problem of how to get the manatees out of there?
> **Belinda:** Well, um, I think that the woman would probably, it would hit her more emotionally because, sure guys might think about animals and protecting them but they're thinking more out of the left side of their brain which is the psychological, orderly type of thing that they do things in a step-by-step procedure, you know, where the woman tends to think more emotionally. And if I was in that situation or in anything like as far as the cholera thing I would just try to get my job done and then collapse. That is the kind of person I am. I would just do my best and just try my best not to think about it and just totally shut my emotions out of the situation and get the job done.

Here, Belinda echoes Jonathan's analysis of this situation -- men are more "step-by-step," women are more "emotional." In her writing on June 1, Belinda said that "I think that a good scientist would use the scientific method whenever he [*sic*] tests things...[S]ometimes I don't remember the whole scientific method, so then I would obviously not be testing things/completing the procedure properly." The man above, in Belinda's speculation, would utilize an "orderly" methodology, which meshes with a vision of scientific practice as fact-based, logical and objective. She goes so far as to utilize the popularized -- and repeatedly, in the past as well as recently, debunked, by feminists and other scientists -- notion that men and women use different parts of their brains to think to explain her reasoning in this area. This is, to me, an example of girls' believing that science disallows the entry of emotion -- and that it would be difficult, for people even less self-reflective than Belinda -- to identify with a position and the daily work of a person who must set aside the emotional aspects of self to do their work.

Belinda views herself as potentially threatened by emotion. She would "just try my best not to think about it and just totally shut my emotions out of the situation and get the job done." She does not state that emotions *should* come into the practice of science, or of medicine -- but that women *are* more emotional, and in order to get the job done they would need to shut down that part of themselves until it was over, and "then collapse." She implies that emotion would *not be* functional in practice or action informed by science such as disaster management, epidemic relief work, or emergency medicine.

So, is Belinda an example of one of those female scientists Jonathan suggested we might draw at random from the total population? Are both she and Jonathan implying that Belinda, with her powerful empathy for those in pain and in danger, should hide herself safely away in a medical laboratory, and not mess with the demand for a cool head that science (and powerful action) demand? Belinda herself insists that it is not acceptable to keep women out of science because they might be more emotional.

> **Elaine:** So what would you say to certain people in the past, and believe it or not, people still say this kind of thing, what would you say to people who say, um, women are too emotional to be scientists, because science is supposed to be unemotional -- what would you say to that?
> **Belinda:** I don't think that that's right, because I'm not a woman's lib or anything like that, but um I still think that um women should be given the equal chance to do that if they want to, not meaning that they have to go out and work construction, or whatever, you know.

Sexism No Longer Exists

> **Misti**: I think that the best scientists are male and female. It doesn't matter what gender you are it matters what is in your head!

Misti's conviction introduces a striking aspect of these girls' and boys' attitudes toward women in the sciences: They insist that men and women are equal now, and that it is unfair and unlikely that women "nowadays" will be kept out of careers due to their sex. But a huge contradiction arises: They also insist -- at least these girls insist -- that women and men are *different* -- they differ emotionally, and differ in their interests. My conviction of this contradiction has arisen from the girls' direct words. For example, Carolyn (below) says that "I think it's interesting to see the females, how they think, how their reactions -- because they think differently than men"; and Belinda's "the woman tends to think more emotionally" (see above). In addition, the girls describe science as a place where certain traits dominate, and those traits are not things that they, as individuals, possess or would care to possess.

Carolyn: Revisioning Science as More Wholly Human?

Carolyn, I believe, hints at a way that we might think of getting beyond the idea that men and women are different, and equal; or alternatively, different, but not equal. Before the excerpt cited below, Carolyn had responded to the question "Can you think of any scientists?" with: "The only one I really remember is Mendel, because [we studied him in genetics]." I then asked her to think of scientists in entertainment media. The ensuing conversation is quoted below:

> **Elaine**: What about scientists in movies, cartoons?
> **Carolyn**: I think that most of the scientists in the movies, and that, are men, because I mean the movies that I watch, if there's a scientist in there you get in your mind that it's going to be a male scientist. Sometimes they surprise you and then they show you that it's a woman scientist.
> **Elaine**: Why do you think the people that make the movies do it that way?
> **Carolyn**: I'm not really sure...I think maybe they think it would be more interesting to have a male scientist.
> **Elaine**: Do you think it's more interesting to have a male...scientist?

> **Carolyn**: I don't think so. I think it's interesting to see the females, how they think, how their reactions -- because they think differently than men. I like to see their reactions to certain stuff.
> **Elaine**: That's a really interesting thing you just said. That men and women think differently, or that women scientists think differently than men. Can you say more about that?
> **Carolyn**: Well, I think that, if they were trying to, mmm, if they were looking at something the men would be more hypothetical and they would be, and I don't think they would really get into it as much, as the women would; they (men? women?) would try and pick it apart. I mean not saying that the men, I'm not trying to be sexist, to say men wouldn't --
> **Elaine**: I know.
> **Carolyn**: -- but I think the women would be more sensitive to the aspect of it, then the men would.

I then told Carolyn that she was saying what a lot of people who study differences between men and women are saying, and that the idea wasn't that one was better than the other, but they were different. I made this point because I was concerned that Carolyn was thinking that she was being "sexist." Then I shared with Carolyn the endangered species, dolphins -- we "pretended" they were endangered -- in the oil spill scenario, complete with male and female scientists. Carolyn began to speak before I finished the question: "Do you think that there would be any different reactions or thinking --"

> **Carolyn**: I think so. The woman would basically think of the dolphins, how they feel, how they would feel about like if they were to put them, to move them somewhere. I think that they would think about, if they wanted to be here, what would they, would they feel bad because it's not as good as where they were before. And the men would just be worried about gettin' them outta there. And making sure that they were safe. But the women would make sure that they're safe, but they'd also think about their feelings.

I was powerfully struck by Carolyn's statement that "I think it's interesting to see the females [as scientists in movies], how they think...because they think differently than men." Again, a student is distinguishing between the epistemological habits of women in general, and connecting them to how women, generally, "also think about their feelings." In Belinda's case, her feelings for the people and manatees with whom she was working would be well near to overwhelming for the woman scientist or health worker. Carolyn voices no such concern here. It doesn't appear as a reason to stay away from this emergency situation, as came through regularly with Belinda's talk.

In addition, Carolyn, unlike Belinda, changed her views about herself as a potential scientist over the course of the semester. I included Carolyn's writing earlier in this chapter as an instance of a girl thinking that she was not smart enough for science; I cite it here again, followed by her end-of-semester writing:

> **Carolyn:** I think that (being a good scientist) means you think well also you make good hypothesis's and you know the whole periodic table of elements...I don't think I have the traits of a good scientist because for one I am not smart, for 2 I don't make good hypothesis and 3 couldn't being to tell you all of the periodic table. (January 30)
>
> **Carolyn** : In order to be a good scientist you have to know somewhat of the case you are studying. You also have to have an interest in science....At the beginning of the semester I really didn't think I had the 'stuff' to be a scientist yet after having a talk with (my genetics teacher) I realized I have a strong interest in science and I don't really have to study anything because I seem to know alot of the stuff even though I have never learned it before. Maybe (my genetics teacher) could get me some info on some of the fields I could proceed in after high school to persue a career that is science oriented. (June 1)

During my interview-conversation with Carolyn, when I asked her if she had ever considered a career in science she told me that, no, she wanted to be a journalist, because her English teacher had told her that she had a talent for writing. When I asked her whether she had ever utilized her writing talent in science, she told me about writing a poem in Earth Science; she wasn't able to recall exactly, but she thought that it was about plate tectonics. I know that I expressed to her that I thought that this was wonderful. It is possible, I believe, that our discussion about the connections between writing and science could have influenced Carolyn's change of attitude toward herself as a scientist; it may have had little or nothing to do with my interest in her belief that women scientists would bring feeling to their work with animals. However, as indicated in the change from her beginning-of-the-semester writing about being a good scientist, the explication of her belief that women would bring more feeling to science has, at the least, not interfered with her thinking that maybe she could, after all, become a scientist herself.

By revisioning herself in relationship to science, whether it was through writing, empathy, or a simple gain in confidence, Carolyn hints at a way that science and science classrooms might be more inclusive of all of human talents, traits, and virtues. She doesn't come out and say, "Science should be different and this is how"; nor does she critique the separation of human traits into masculine and feminine camps. Therefore she is not directly getting at the issues of science and gender that I had hoped to help my students reveal and discuss. Neither, however, did she appear threatened by a critique of a much-loved subject the way her more successful science classmate Jonathan did. On the contrary, she shows a twinkle of interest that was totally absent in her earlier expression of herself as a scientist.

Kidmark B: Summary

Some of the students who contributed to these data separate themselves from science by saying that they are not smart enough to practice science. Ann views her brother as explicitly supporting this belief -- a man would just be better, period. Jonathan more subtly denies the average woman the logical acuity to conduct "excellent" science. Carolyn Tammy, Belinda and Jennifer identify themselves as either not smart enough, lacking in knowledge, or incapable of properly practicing the "scientific method." This leaves little doubt in my mind that these girls are excluding themselves from science because they perceive it as beyond their intellectual talents.

Belinda and Carolyn add to the complexity of the relationship -- or lack thereof -- between girls and science. As also indicated in this analysis, students are envisioning women as possessing emotion, something that is not present in traditional representations of science. They bring in (as does Jonathan, briefly) a conviction that women are "more feeling" than men. They would not leave these feelings behind in their scientific work. The trait of "empathy" is foremost in Belinda's speculations about a woman scientist responsible in life-threatening situations. Her portrayal of empathy and science is one that does not appear to allow for their compatibility.

Carolyn's view is different, possibly because she had not put the time into struggling with this issue, as had Belinda with her concentrated thinking about her career choices. Carolyn clearly states that women would bring more "feeling" to their scientific work. This feeling takes the form of empathy; the woman scientist "would basically think of the dolphins, how they feel, how they would feel about like if they were to put them, to move them somewhere." However, Carolyn does not indicate that female empathic feelings would be a reason for a woman to choose not to be a scientist. In fact, she thinks that "it's interesting to see the females, how they think...I like to see their reactions to certain stuff."

These students didn't make the leap from "women are caring" to "science could be caring." Their claims ranged from those that implied that the average woman, with some effort, could be just like a man in science, to ones that recognized difference as a positive addition to science, not because of masculine and feminine "differences" but because individual scientists would be different people. Nonetheless, they left science itself unquestioned.

Wavering on the Border of a Feminist Critique of Science as a Social Enterprise

As described in Kidmark A and Kidmark B, these students are addressing the kinds of issues that I would hope would come up in discussion that involved matters of "science as a social enterprise," and while some of their theories about women and men in the sciences match well with both standards (e.g. men and women are equal; both can succeed) and feminist (men and women are equal and both can succeed; men and women are different) ideas, they are not taking their conceptualizing to places that I would like it to go. They are not saying that empathy *could or should* be a valued part of science. They are not making that leap from "men and women are different" to "science is constructed along masculinist lines and therefore excludes the practice of traits that are traditionally considered feminine." In terms of objectivity, although they question the human and their own personal ability to be objective, they do not adopt a critical stance toward science that might help them think that science itself is not only practiced by people who are no less human than themselves, but that science might be constructed along ideological lines that no one can follow.

Kidmark C: Science and Social Values

Kidmark C demonstrates that students themselves constructed a powerful critique of "science as a social enterprise" requiring no input from me. Students make very clear and straightforward statements concerning what they think the role of science in society should be. In Kidmark C, students get very close to reimagining science as a human effort that is embedded in and responsible to people and to the Earth.

The writing samples below come from students' responses to the questions I assigned on January 30 and June 1. Please recall that question "C" was added for the June 1 assignment.

A. What does it mean to "be a good scientist"?

B. Do you have any of the traits of a "good scientist"? Why, why not, some yes, some no?

C. Have you or your ideas (those that you talked about in A and B) changed at all since the beginning of the year or of the semester? Please explain how and why they have or have not changed.

A couple of responses are also drawn from students' writing as part of their final exam in biology from the semester before they took genetics. I have included in these data only the students who continued on with me in genetics. This writing is dated January 20, 1996. It is in response to the question:

> We spent a few days discussing the concept of stereotypes of scientists, and how scientists we could imagine could be different from these stereotypes. Explain your position on this issue. Approach it however you like -- humor is allowed -- but take it seriously, nonetheless.

<u>"A Good Cause"</u>

Students regularly informed me that they believed that scientists should do research "for a purpose" (Becky, January 20). This is distinctly different from a blind search for knowledge that is part of a popular stereotypical vision of scientific work. In making this claim, students are making a powerful connection between science and society. Whether or not the development of scientific knowledge is "objective" or denying or welcoming of "empathy," these students represent science's role as firmly grounded in social responsibility.

> **Nina**: I think the number one thing a good scientist must have is a good cause. One that needs to be solved for today's society. Get all the necessary data and ideas. It's also important not to harm any living things or alter their environment in any way to conduct testing (January 30).

> **Kari**: A good scientist is someone who follows the law in everything he/she does but is willing to experiment. A good scientist goes farther into asking questions than anyone. Most popular good scientist makes an invention or law that is used by certain people and is used on and on through generations (January 30).

Nina's "number one" consideration does not mesh well with science as currently practiced. It is also notable that she apparently interpreted "good" as a moral question, while most other students interpreted "good" as successful and accurate. Interestingly, her classmate Kari brings both forms of "good" together in her commentary. Intrigued by Kari's comment, I asked her in class the next day what she meant by "law" in this context. She explained that she meant human law, legal law -- not, for example, the laws of physics. So again, she is bringing in the moral or ethical demands of scientific activity.

Other students responded to these questions as follows. I have arranged them in what I see as revealing increasingly "militant" voices in terms of what science and scientists "should" do.

> **Kevin:** I think (a) good scientist helps other people in their work. For example: A scientist who finds a cure for aids or somthing like that. They have to be decicated to thier work and try thier best at it (January 30).

> **Becky**: (accompanied by pictures)...The nonsteriotypical scientist is either a man or woman. Has normal hair and researches for a purpose, not just to blow things up (January 20, Biology final exam).

> **Becky**: Research, good observations, experiments, testing for certain things, being interested in making the world better (January 30).

> **Alex**: I believe science as a whole needs people with morals...The way science is going, more "moral" people have to go into science to make sure what they are doing is in the good of all mankind & the entire world (June 1).

> **Nina**: To make advances that benefit people. The good scientist must not alter their environment in any way to make these advances though. A good scientist can't harm or kill anything simply for the sake of killing it (June 1).

Kevin wants the "good scientist" to "be decicated [dedicated]" and find "cures." Becky's demand is a bit more vague: While she views scientists as sometimes conducting research "just to blow things up," she hopes that they will find a different, presumably more constructive "purpose." Becky wants scientists to be "interested in making the world better"; she isn't as specific as Kevin, although she becomes more so in the following writing. Alex, as I have already discussed, explicitly recommends the entrance of more morality into scientific practice. Nina is the most clear and implicitly political in her representation of science's responsibility to society, particularly in her protective environmental stance.

During the four-way interview-conversation (Jonathan, Sam, Alex, and myself), I asked the three boys what they thought about the possibility of a scientist as someone who "wants to make the world a better place." In asking this question, I was drawing on what I had learned from students' writing, as exemplified above. Jonathan, our staunch defender of objectivity, said, "That's probably one of the, of the fundamental goals of practicing science, to make things better. I have a hard time seeing any other [reason]." While Jonathan's examples of socially responsible science -- "genetic engineering" and "better ways to make frozen foods" -- don't have the passion of Nina's, they do indicate that science is supposed to produce things and ideas that, on some level at least, benefit humanity. In addition, Jonathan's comment refuses a notion of knowledge for knowledge's sake.

<u>"In the Interest of All Humankind"</u>

Kevin, above, expresses his belief that scientists should work to find cures. He brings in AIDS as an example of something that scientists should aim to "cure." This isn't surprising, given AIDS's prominence in the media and in the high-school curriculum. Therefore I made the decision to place a question about the role of science in society in the context of medical research, specifically, deciding what kinds of research should be funded. I also made this decision because of the common requirement that students had for scientists, that they work to find "cures." The transcript excerpts below demonstrate both Ann's and Alex's thinking in this area, drawn from the interview-conversations I conducted with each of them.

Ann and AIDS

> **Elaine:** (L)et's say you had to decide...between two research projects that wanted your money....One of them was to work on finding a cure for AIDS....And one of them was to work on developing a faster computer....Which of those would you want, vote for --
> **Ann:** The AIDS --
> **Elaine** Why?
> **Ann:** -- because many people are dying of it and some people like, if they got a blood transfusion and that might, and that's how the AIDS came in, then I think they should pick it for that. But if it's through sexually -- I, it's their fault, that it happened. But still I think that it should be AIDS
> **Elaine:** ....I'm wondering what you think (about) like who should get treatment. Does, does it matter to you how somebody got it, if they should get treatment or not?
> **Ann:** Actually, it don't matter. They still need to be treated cuz, I don't know, some people don't deserve it; nobody deserves it, actually.
> **Elaine:** Deserves to have the disease?
> **Ann:** Yeah. Everybody should be treated. I think so.

Out of all the questions and scenarios I put to Ann, this was the one that inspired the longest response. In addition, her response indicates the kind of "thinking through" an idea, with all the self-questioning and eventual clarity that that entails, that I wanted students to engage in. Most students did so during these interview-conversations, and even sometimes in their writing. Ann was not usually one of them. On the subject of AIDS, however, possibly because it is a topic that she has spend time learning and thinking about, she was able to bring enough knowledge, and enough of her own beliefs, to the question to provide a reasoned (and caring) argument for the financial support of AIDS research as opposed to more technological work of computer development.

During the individual interview-conversation with Alex, I proposed to him a similar scenario. Directly before the scenario, Alex had explained his qualified support for science:

> **Alex:** I'm all for science, as long as it's, you know kept under control, and not just let...to do whatever they want to....I'd really want to make sure that...it was in the best interest for humans....I mean if it's in the best interst of the entire little ecosystem....I mean because we're all related...I mean we can't kill everything, because I mean then that would screw up...the whole ecosystem you know and the food chain would go berserk.

We had been studying contemporary techniques of genetic engineering in genetics class, along with the ethical issues that this work brings to the fore. Jonathan had argued in class that he thought that it was fine to use genetic technology to allow a man or a woman to have a child "alone." In addition, Jonathan stated that he had no qualms with introducing genetic material into the fetus in order to confer upon it the traits that the parents desired. The transcript picks up after my reminder to Alex of Jonathan's comments.

> **Elaine:** Let's say...somebody wants to do something like that. Say they want to do an experiment with say 1000 babies to see if they can put a gene into them to, I don't know, make them all, I don't know, ah --
> **Alex:** As smart as Jonathan? (We both laugh.)
> **Elaine:** Yeah -- this is problematic. Because there's not, nobody's, there's no one single gene for intelligence ---
> **Alex:** Right.
> **Elaine:** -- and that's all a mess anyway but, for hypothetical purposes, what would you say to that particular case?
> **Alex:** Well, I don't know. I have this, from what I said earlier, if it's you know, in the interest of all humankind, I guess that would be okay. But I don't know, I have this feeling right now that I don't think that I would like that.
> **Elaine:** Do you think that doing that -- I mean, that was your basic rule, in the interest of humankind, and taking good care of the ecosystem, which are related ideas -- do you think that that experiment would be in the interest of humankind?
> **Alex:** Well it's, I think it's kind of like playing God. It's kind of like changing the rules and such; I don't know whether that would have an effect. I mean I know, I don't know, I just have this feeling like that I wouldn't want that to be done for some reason. I don't know why...I have this feeling.

Alex utilized an intriguing combination of science and religion to make his case that care for the ecosystem and humanitarian interests should be criteria for deciding what scientific research should be funded. He brings in his scientific knowledge of the food chain: because "we're all related," we must make certain that we not "screw up...the whole ecosystem you know and the food chain would go berserk." He also explains his discomfort with "playing God." However, even this theological stance is informed by a scientific stance, one that an evolutionary biologist could identify with: "It's kind of like changing the rules and such; I don't know whether that would have an effect." We continued to explore his thinking in this area.

> **Elaine:** Do you think that there's a different in the -- like say somebody applied to you for money and they said they wanted to um insert genes in people to make them smarter and somebody's competing for that money and they say they want to insert genes in people that will make them not have hemophilia, people that normally would. Would you --
> **Alex:** Where will I give my money?
> **Elaine:** Yeah.
> **Alex:** I probably, well I know I'd probably give my money to the (pause) -- I don't know.
> **Elaine:** Interesting.
> **Alex:** Yeah. I was, I was, I, on instinct I was just gong to say give it to hemophilia.
> **Elaine:** Yeah, that's what my instinct is too.
> **Alex:** But --
> **Elaine:** Maybe I haven't thought about it enough.
> **Alex:** Yeah, um, let me think here. I don't know, I don't like, I don't like playing God, for some reason. I think He set up this world the way He wanted it to -- even though Adam and Eve kind of changed that, but, He set it up, He set it up where, you know, a man and woman leave their families, get married, have children, you know, in kind of a set order. I don't know, I think it's kind of, I don't know whether it's wrong or not because I'm not sure if you know, I know, when John or someone, wasn't when he was writing this had no idea of the technology that we would have, you know, today.

Alex surprised me, and I think, himself, by not automatically saying that money should be given to researchers who were trying to alleviate the suffering of hemophiliacs. His argument rests on the idea that "God" set up the world the way he wanted it; and again, that we should mess with that God-given order. However, he realizes that when the New Testament was written, its authors had no idea that the future would hold the problematic technologies of genetic engineering. While I find this humility and thoughtfulness attractive, it seems to contradict Alex's otherwise strong stance that moral issues should be addressed in scientific work. It moves almost into a laissez-faire attitude toward human suffering, one that would certainly make it difficult for researchers with "all humankind" in mind to attain funding.

The place of genetic technology in human life presents a moral dilemma for Alex. His conflict is between the religious demand that he should obey and praise God and a wider humanitiarian demand that he help other people. However, I don't want to leave readers with the impression that Alex was "antiscience." I am sure that it was quite the contrary. He demonstrates so in saying, "I'm all for science." The statements above, as well as the quote below, exemplify the sophistication and complexity of thought that I believe standards writers and academic feminists do not attribute to young people.

> **Alex:** I don't believe that we should not mess with *anything*, because I mean that's how we've gotten this far as...a people and as a society because we've kind of messed with Mother Nature, that's why we have certain luxuries.... I don't want anybody go cutting down the forest looking for some cure for cancer but I mean I don't want us to just sit on our duffs and say, 'Oh God will provide a way.' I mean, I know that's the truth, but...there has to be a happy medium.....Some people don't take faith at all, and then some people take faith to...wild extremes, saying you know 'we don't have to do anything...God will provide.' I mean, God helps those who help themselves.

Kidmark C: Summary

These students' ideas about science and scientists' responsibility to society focus on *reasons* to do science that are not present in the traditional or standards-based cluster of scientific values and virtues. They open up science for the inclusion of traits and actions associated with politics, social action, and personal conviction. In their descriptions of what makes a "good scientist," the students portray science as no longer above or separated from social and humanitarian concerns -- whether or not it can be, it *ought not to be.*

These students' responses to these questions indicate an attitude toward science that puts kids, and not scientists, in control. For example, Ann wants all people with AIDS to be treated. This issue inspired the longest, most "thought-through" response from Ann that I witnessed the entire semester. What might she learn about the issues of money and power that permeate medical research, both practically and ideologically, if she were given the support and time to pursue her conviction? As Ann's science content mentor, guided by the standards, I would see this exploration as an opportunity for Ann to expand her knowledge of epidemiology, statistics, and the genetics of viral infection. As a feminist, I would like Ann to encounter issues of who gets included in "big big studies" (see Sam, above) and how these choices relate to issues of gender, race, and class. In addition, as a feminist, I would hope that Ann's views of sexuality and responsibility might also be enlarged and complicated.

Alex used something akin to risk-benefit analysis in making his determinations of what research should be funded. This connects to the standards requirement that students learn to utilize scientific knowledge to make societal decisions. Alex uses *both* science and religion to come to his tentative conclusions. In addition, he's not just using science to decide whether or not it's allowable to have a nuclear power plant in his community or introduce genetically altered plants into agriculture. What he's doing is using risk-benefit analysis to decide what kinds of science researchers ought to engage in. As Alex's science teacher, I would like to push Alex further on his insistence that God had planned the world to accommodate men and women, and that they each had their designated roles in life.

The young adults whose ideas provide the material for the analysis in this dissertation are just now graduating from high school. They have grown up conscious of a world that includes chemical pollution, threats to Earth's ecosystems, and epidemics of disease and starvation. They see in science some hope for the alleviation of these woes and dangers. They also understand, I believe, that science itself has played a hand in the development of these deadly situations. Their views of science and society are not "simplistic," but clear-sighted and imbued with a sense of responsibility that science owes to the world. Most exciting to me is their powerful insistence that science should "do good" for humanity and for the Earth. This is not something that I expected. They seem to want science to be a democratic, moral project: science to make cures; science responsible to humans, animals, and the environment; science, at the least, to "do no harm." These ideas deviate drastically from a version of science that calls for it to seek knowledge for its own sake.

Discussion: Learning from Students about "Science as a Social Enterprise"

What did I, as a high-school genetics teacher, learn from these students about how to teach "science is a social enterprise"? First and foremost, I learned that students' thinking was both in concert with the standards and extended beyond what the standards represent as the virtues and values of scientific practitioners. I believe that students, therefore, are a richer resource for learning about science as a social enterprise than are the standards themselves. The latter tend to look somewhat constrictive when compared to students' more wide-open and idealistic visions, particularly concerning the role that science could play in developing a just world. Providing students with contexts within which to explore their beliefs about scientific practice may enable them to learn to challenge the stereotypes of scientific practice that permeate society. They may also, with more time than I provided for the students in this study, develop ideas that succeed in revisioning science as an enterprise that fulfills their visions for it.

In terms of intellectual understanding of scientific practice, I was powerfully struck by students' insistence on objectivity and scientific method. According to the logic of objectivity: if all involved are doing their jobs, women and men would not do science differently; at the least, if they followed "the scientific method," they would all eventually end up in the same place. One aspect of traditional objectivity is the separation of the knower from the known, as well as of the knower from her/himself, from society, from belief systems, from emotional considerations, and from desire for knowledge for purposes other than "for its own sake." This separation plays into a portrayal of science as free from social and personal influences. In addition, the standards imply, although don't unequivocally state, that emotion doesn't belong in science: "Reasoning can be distorted by strong feelings" (AAAS, 1993, p. 232). The assumption that emotion *can* be removed from the practice of science is one that these students question.

The girls in this study note that women would bring to science the practice of traditionally feminine trait of "emotion." But, paradoxically, they still seem to recognize an apparent imperviousness of science to emotion. Girls need to leave huge parts, defining parts, of themselves behind in order to engage with what they see as an unemotional, asocial, and purely intellectual science. On the other hand, Jonathan can engage passionately with science: It has provided him with a powerful explanatory and widely acceptable world view -- possibly, even, it has taken the place of the religion of his heritage. This passion may be consider a kind of emotion -- but is it "caring" or "empathy"? The kind of passion that Jonathan portrays so well is one that is well accepted in science; it is an intellectual passion, the desire to know and understand the world. It is not one that concerns itself for or with the "object to be known." Intellectual passion as Jonathan evinces it is welcome in traditional scientific practice. A caring passion, an identification with the "object to be known," is one that gets in the way of objectivity, and has traditionally been spurned in Western science.

Empathy is not a valued scientific virtue. It is not in the standards documents as a methodological, or epistemological, or intellectual virtue. In fact, scientific objectivity -- as traditionally portrayed -- tries to omit empathy. This leaves a lot of girls, and other people who identify with the traditional trait of caring and feeling in relationship to others, alienated from science. It also leaves out a whole chunk of being human, and thus allows the perpetuation of a myth of objectivity as an attainable and desirable distancing from social life as well as the objects or subjects under study.

I find Evelyn Fox Keller's image of dynamic objectivity (see p. 57, this chapter) very attractive in light of what these students have taught me about their scientific epistemology. This image is one that loses neither the scientist nor that which is to be learned about. The consideration of empathy as an aspect of knowing provides possibilities for studying our world through a way that includes and utilizes *all* of our personality traits, *all* of our virtues, and *all* of our talents. It puts into question the sets of values and virtues that the standards have put forth, a set of traits that is at best partial, at worse inaccurate and exclusionary.

I was also intrigued, and somewhat troubled, by students' separation of "male" and "female" into traditional masculine and feminine camps. I noticed that they associated traditionally masculine traits with science, and that many of the girls dissociated themselves from science. All of these things go along with typical oppressive views of women and of science. All of these things would be things that I would want to help students address head-on, rethink, interrogate, and have experience with, using examples from history, contemporary medicine, and other domains.

These students name the values and virtues of a "good scientist," both those present in popular stereotypes, and, sometimes, the more progressive, humanitarian scientific norms set forth in standards documents. The students in this study want science to "care" about people and about society; they believe scientists should exercise moral judgment; they wonder if women can succeed, as individuals, or if it would be too painful; they see women and men as bringing different, although possibly complementary, values and virtues to science. The rhetoric employed by the standards' authors encourages students to recognize the positive values and virtues that science requires and demonstrates; wants them to see them and practice them in science and science class; wants them to use them as a reason to value science itself, and to use the knowledge that science has produced to inform their personal and social choices. Students, however, have values of their own -- and they want science and scientists to satisfy these -- not necessarily the other way around.

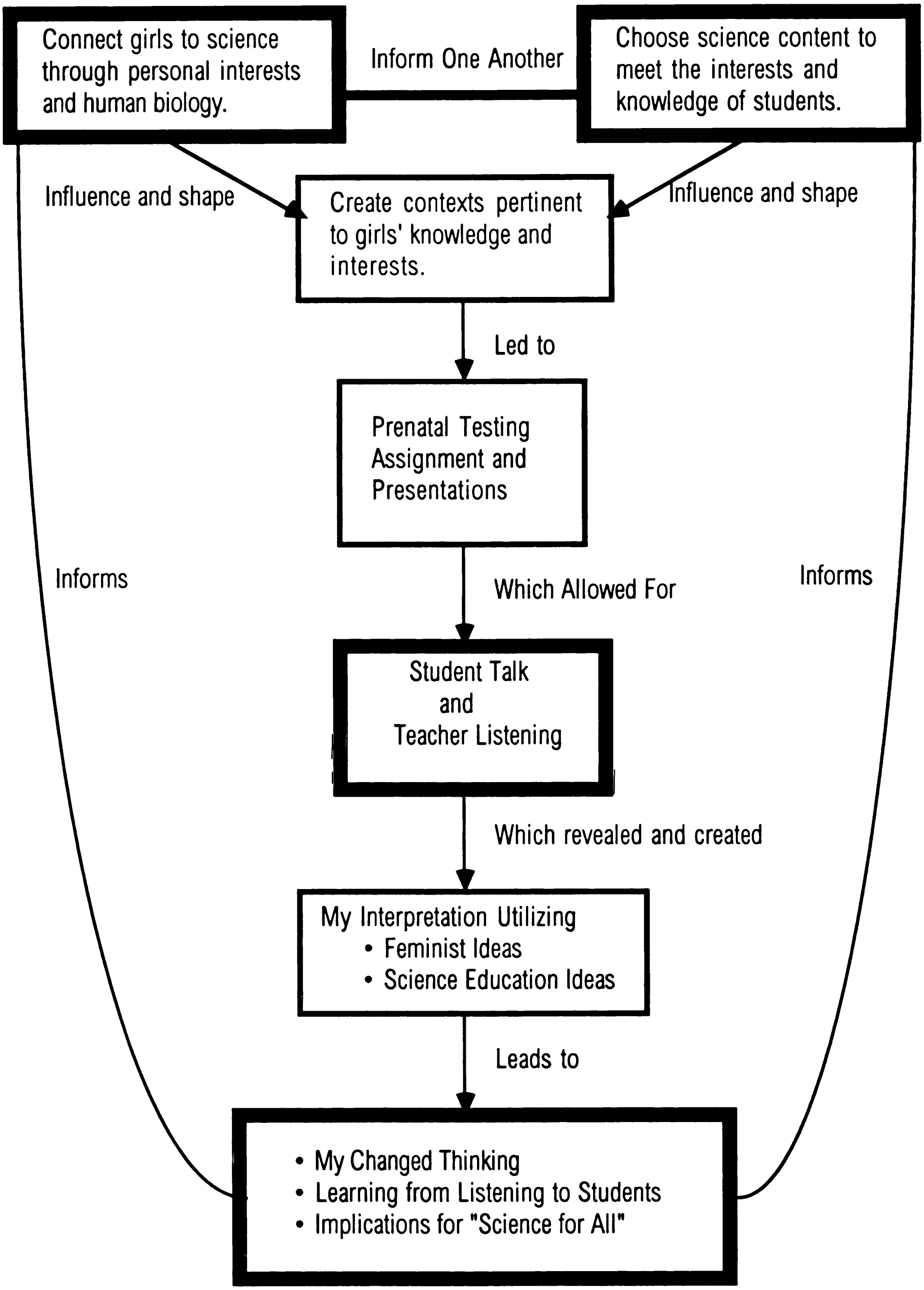

Figure 4 - Flow Chart Chapter V

FEMINIST PERSPECTIVES & PEDAGOGY

[When girls are intrigued with science] there is often a special emphasis on the relevance of science to social issues (Mason & Kahle, 1989; Stage, et al., 1987) and to everyday occurrences with which girls are likely to be familiar.
Nancy Brickhouse (1994), p. 3.

3. Incorporate and validate personal experiences women are likely to have had as part of the class discussion or the laboratory exercise. [and]
20. Discuss the practical uses to which scientific discoveries are put to help students see science in its social context.
Sue V. Rosser (1992), pp. 128-129.

SCIENCE EDUCATION STANDARDS

Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.
NRC (1996), p. 30.

Biotechnology has contributed to health improvement in many ways, but its cost and application have led to a variety of controversial social and ethical issues.
AAAS (1993), p. 207.

Sound teaching usually begins with questions and phenomena that are interesting and familiar to students, not with abstractions or phenomena outside their range of perception, understanding, or knowledge.
AAAS (1989), p. 188.

DIFFERENCE FEMINISM

Why difference feminism can be a powerful analytical perspective:

[H]istorically, scientific values were not constructed in gender-neutral terms. Science, like masculinity, was constructed as objective, value-free, individualistic, and disinterested, but cultural definitions of the feminine were defined in opposition (Harding, 1986; Keller, 1985). The division of emotional and intellectual work serve to exclude women from the practice of science and to exclude values traditionally regarded as feminine from science (Keller, 1987). Even today, success in science frequently requires the abandonment of characteristics that the culture labels 'feminine.'
Nancy Brickhouse (1994), p. 10.

Why we must remain conscious of stereotyping dangers and totalizing tendencies of difference feminism:

Although one major theoretical approach of feminism has been to assert the essential sameness of women and men, and thus women's claim to equal treatment, another prominent strain has formulated a psychological structure, a politics, and a pedagogy that celebrates women's particular attributes -- a set of theories based on 'difference.'... But such ideas about the essential commonality of all women, represented by a phase of feminist theory known as 'cultural feminism,' demonstrate a failure to take into account those differences *among* women, such as social class, heterosexual privilege, and whiteness.
Frances A. Maher & Mary Kay Thompson Tetreault (1994), pp. 222-223.

Markers of Difference Feminism

• Women are biologically different from men, in that they can conceive, carry and nutritionally provide for fetuses and infants from their own bodies.

• Women carry two X chromosomes; men carry an X and a Y. This is the only difference between the chromosomes of men and women.

• Girls and women, because they are raised to nurture -- physically, emotionally, and psychologically -- the species' young, demonstrate the following traits:

* Connectedness

    • to other people
    • in terms of learning and knowing
    • to the Earth and to nature

* Centrality of relationship

* Use of morality of care as well as morality of justice

CHAPTER V
PRENATAL TESTING: CONNECTION AND ALIENATION

In this chapter I explore how a set of high-school sophomore girls expressed their relationship to and understanding of prenatal testing, and its possible place in their lives and in the lives of others. The data come from an assignment I designed to help students bring their understanding of prenatal testing into the realm of personal choice, as well as practice applying the science of chromosomal inheritance. Here, two demands come together: Difference feminism requires that we recognize and value girls' interests and knowledge; and progressive science education requires that we help students make connections between science and students' "real worlds." The instructional choices I made were based in "difference feminism," which I interpreted as implying that girls would be interested in science that connects to human bodies, children, and traditional women's responsibilities. This hypothesis is complicated by this study, in which I concentrate on the question: How can difference feminism help us better to hear and comprehend high-school girls' relationships with reproductive technology, their own bodies, and their own lives?

Difference Feminism: Connecting Girls to Science

Difference feminism focuses on the differences between men and women. This aspect of gender studies is in itself nothing new; in fact, it carries within it the capacity for reactionary and repressive power. However, it is also potentially revolutionary. For example, such authors as Carol Gilligan *et al.* (1990) and Mary Belenky *et al.* (1986) have insisted on studying *only women*. This is in itself a radical act: In our patriarchal society, men are kept as the standard and the rule; women are viewed as unfinished or improper men. Therefore by making the moral, psychological and intellectual development of girls and women the sole substance of their studies, these researchers and their followers are denying the focus on men that has characterized work in human moral and intellectual development.

The studies of Gilligan and her colleagues come from and add to psychological developmental issues. A separate, although related, aspect of difference feminism consists in the biological differences between male and female human bodies. Out of the myriad activities that humans participate in and carry out in order to survive and thrive as a species, pregnancy and childbirth are uniquely female. This biological fact is used by radical difference feminists to claim that women are mystically powerful because they can "bring forth life," and thus identify with Mother Earth (Daly, 1990; Merchant, 1980; Schiebinger, 1993). It is stated as a reason, historically and anthropologically, that women have been and continue to be oppressed in the great majority of world cultures (Lerner, 1986; Rubin, 1975). It is also, in legal and work situations, a fact that is used to keep women from attaining permanent and potent positions of power (Lorber, 1994; Pollitt, 1995). For these reasons, topics tied to pregnancy are of concern to me as a feminist science teacher.

The ability to be pregnant is the prime difference between human biological females and males. Because women conceive, carry, birth and nurture new life, they have historically been associated with images of fertility and nurturance. They have also been assigned the emotional and practical knowledge and talents that attend the roles of child-bearer, child-protector, and child-feeder. According to difference feminism, women learn these roles from the moment their biological sex is determined -- they learn to care for others; they learn to identify with others' emotions, pain and fear; they learn to manage relationships so that they benefit everyone involved, not necessarily, but often, excluding themselves. These identifiers of the feminine encourage women to behave in certain ways, resulting in a set of assumptions that puts women in charge of children, human connection and compassion, on an everyday basis.

Following this line of reasoning, then, women learn to be in the world and in relationship in ways fundamental to their identification as female. These claims are problematic; and in any case, they may not be provable, one way or another. But they retain considerable power to socialize women into certain ways of behaving. The biological certainty that women bear children becomes the justification for the maintenance of status-quo beliefs about roles of men and women, and subsequently, the justification for training and expectations that distinguish boys from girls and aim to help them fit into their gender assignments.

Two Caveats: Privilege and Essentialism

This chapter marks my efforts to apply the controversial theories of difference feminism, which argue that women and men possess certain interests and psychological traits due to biology, socialization, or a combination of both (e.g. Barbieri, 1995; Belenky *et al.*, 1986; Gilligan, 1982; Gilligan *et al.*, 1990; Rich, 1986; Tannen, 1993). The perspectives of what I am calling "difference feminism" are very powerful for me, both because they help me to explain my own relational world, and because they have suggested theoretical frameworks for studies in coeducational science classrooms.

Nonetheless, my first caveat consists in my recognition that these ideas have developed greatly from studies with White, middle- and upper-middle-class adolescent girls and women. For example, Making Connections: The Relational Worlds of Adolescent Girls at Emma Willard School (1990) is the result of longitudinal studies of the developing moral lives of adolescent girls at a private school. Thus their sample group represents privileged women growing up in financially secure -- even wealthy -- circumstances.

The second caveat arises from my biological sensibilities. As a feminist in the life sciences, I am painfully aware of the ways that my chosen discipline has been utilized to maintain oppressive and undemocratic gender roles. The type of difference feminism that claims special connection to the Earth, to other women, to children, to peace and to the cosmos, can sometimes be spiritually comforting. But it becomes dangerous when it slips into the claim that behaviors commonly thought of as feminine or masculine -- for example, nurturance or aggressiveness -- are "natural." I want to make it very clear that I do not operate from the assumption that women possess the traits delineated by difference feminism directly because they are *biologically* female. As soon as babies are identified as male or as female, a whole set of gender socialization activities goes into motion. Therefore the gendered behaviors noted by difference feminists may result from the facts of sexual biology; but they are not the *biological* result -- they are the *social* result. And therefore, they can change -- socially, individually, and across sexes.

I aim to keep these caveats in the front of my mind as I study these students' words and work. I ask the reader to do the same. It is the tension between recognizing the value of traditional feminine traits, while insisting that they are not natural or immutable because one is biologically or socially female, that holds both the most trouble and the most potential for difference feminism.

Science Education: Connecting Students to Science

Contemporary science education reforms, based in the egalitarian ideal of "science for all," urge teachers to help students connect to science via a recognition of students' existing interests and knowledge. This idea recognizes the constructivist learning tenet that students come to the classroom study of phenomena with theories of their own, developed from their experiences and learning in other contexts. Thus, for example, my students had heard of amniocentesis; they had an idea of what it was, from health class, television, and relationships outside of school; and they had tentative explanations for its purposes.

As noted in the quotes that head this chapter, the standards documents explicitly state that teachers should attempt to choose themes and activities that help students to connect science to their "real lives." However, there is no mention of how teachers might specifically connect *girls* to science. This is a place where the standards documents open up an area for exploration in the pursuit of "science for all"; a place where we can set aside the overall rhetoric to explore its fuller implications.

Researchers concerned with the underrepresentation of women in science and the lack of success of large numbers of girls in science have developed suggestions for this effort (AAUW, 1992; Brickhouse, 1994; Rosser, 1992; Sadker & Sadker, 1994). These studies have come up with a common conclusion, summarized here by Myra and David Sadker:

> [G]irls participate less in science class, allow boys to take over the lab equipment, and watch male students conduct scientific demonstrations. As in the case of math, they do not understand the usefulness of science to society or to themselves. Many girls say that science makes them feel stupid (1994, p. 124).

In the AAUW's study, How Schools Shortchange Girls, the authors found that girls lag behind boys in achievement in all of the sciences, with biology showing the least difference (1992, p. 26). For whatever reasons, girls appear to be more interested and more successful in the biological sciences. The national standards touch lightly upon it; studies focusing on girls help to deepen our understanding. What can we do to help girls believe that science plays an important role in their lives? How can we help them learn to feel smart, rather than stupid, in their encounters with scientific knowledge and practices?

Along with these well-documented and publicized studies come recommendations for the development of curricula and pedagogy that will more closely match the interests of girls and young women. In general, these recommendations indicate that scientific content explicitly based in the experiences, feelings, and interests of girls will help us to develop curricula and pedagogy that attract more girls to science. Difference feminism, in particular, helps to illuminate these possibilities. Attentively and openly listening to girls, studying their interactions with a curriculum aimed to hook up with the interests that I tentatively assume they hold, we may learn something about how to teach science so that it more successfully connects to girls' lives. In addition, we may ourselves learn to value the experiences and the knowledge that *girls* bring to *science*.

My Thinking as a Teacher

As a teacher, I recognize that students are intrigued by things that are close to them. They often bring to science class their questions about their bodies and the anatomical and physiological conditions of other people. They revel in discussions and learning about things that human bodies can do, in normal and especially in weird circumstances.

However, my own ability to predict what will intrigue my students often falls short of their own ability to ask questions that I had no clue as to how to answer. The pedagogical challenge is to connect teenagers' fascination with the new and bizarre to the everyday and the mundane, which is what most of basic genetics involves. The prenatal testing assignment described below was an attempt on my part to intrigue students with the details of genetic screening in such a way that it would help them to develop their understanding of chromosomal and gene inheritance, which was the basic stuff of genetics that we were studying.

I especially hoped that girls would connect with this assignment in ways that would lead to a confident comprehension of the techniques and scientific bases for prenatal testing. The subject of prenatal testing affords a potentially productive realm for the study of connections between science and women's lives. The time-honored feminist statement, "The personal is political," is nowhere so pertinent as in the arena of reproductive choice. And because women, not men, conceive, incubate, nourish and birth new human beings, it remains the one thing that we hold (at least for now) certainly in our grasp. Pregancy and childbirth are things that women, *not* men, can do. Thus images of women as "live-givers" attract both images of power and competence, and images of tenderness and its attendant frailty.

<u>The Prenatal Testing Assignment</u>

The assignment required students, in self-selected groups, to choose and study a particular prenatal test of their own choosing, and then plan and present their learning to the class in the form of a role-play. Up to this point, students had been studying ultrasound, amniocentesis, chorionic villus sampling[12], and Alphafetoprotein (AFP) testing[13] using an age-level genetics text (BSCS, n.d.) and my lecture. For work on presentations, they

[12]Chorionic villi sampling is a prenatal test in which the embryonic chromosomes are obtained by taking a sample of the villi that line the chorion. The chorion is made by the developing fetus, therefore its cells contain fetal chromosomes.
[13]AFP is a protein produced by the developing fetus. High levels in the mother's blood indicate at least threeo possibilities: One, that twins are expected; two, that the fetus has Down's syndrome; and three, that the fetal spinal cord is not developing properly.

utilized college and graduate level texts that I provided, with the assistance of Barb Neureither's generous loan of her own bookshelves.

The roles that I suggested were "doctor," "pregnant woman," her "husband"[14], and a "concerned relative or friend." The questions that I required students to address in the presentation were:

• Why is the doctor recommending this test?

• During what time period in the pregnancy is this test used?

• What, specifically, do geneticists and doctors use this test to find out?

• What are the possible dangers of this test?

• Would you choose (or encourage your wife to choose) to have such a test?

• Do you think that women should be required to have such tests?

As in any bioethics study that involves delicate and private issues, I did not demand that any student participate if s/he were uncomfortable. All students chose to participate. Students generally adhered to the roles that I suggested, with exceptions when the size of the group or its makeup encouraged students to play "sister" or "brother" instead of or in addition to "husband." Two groups chose to forgo the play and present their information and beliefs in a more straightforward fashion.

Student presentations are one way for a teacher to give up the floor, thus upsetting the typical knowledge hierarchy in which all ideas emanate from the teacher. In addition, they create situations in which students talk directly to each other, both during the planning process and the presentation itself. This allows for a special kind of teacher listening, distinct from that which goes on during typical class discussions (Cazden, 1988; Lemke, 1990) in which one student speaks at a time, then the teacher, then another student, then the teacher, and so on. When students are in charge of presenting ideas, their words needn't continually be filtered through and reinterpreted by the teacher. Thus the students can hear

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[14]I chose "husband," instead of "partner", to avoid possible negative repercussions from students or parents concerning out of wedlock birth or same-sex relationships. This choice was not comfortable for me, and is something I would do differently next time.

each other, and the teacher can listen to the students, as they portray knowledge, question each other, and develop public understandings of ideas as well as clarify and externalize individual beliefs and comprehensions of the scientific content.

I designed this assignment concerning prenatal testing partly to explore the research-based hypothesis that girls would be attracted to science that they could connect to their bodies and their lives, present and future (Brickhouse, 1994; Rosser, 1992). Because, like pregnancy, the direct physical experience of prenatal testing is something that only a woman could have, it provides a context within which women's bodies and lives are central. My goals for this assignment were to support students in applying the science of genetic inheritance theory in order to comprehend the technology, and to begin to struggle from scientifically informed perspectives with the ethics involved in reproductive choice. I wanted to give them practice with the scientific concepts that we had been working with throughout the semester: meiosis and mitosis; the connections between genes and physical traits; the contributions that each parent makes to offspring, and the effects of gene and chromosomal mutations. I hoped to support them as well in exploring their own beliefs in a context that might mimic their future experiences as pregnant women, as concerned others, as doctors, and as scientists faced with difficult and subtle scientific and personal issues.

My goals for the activity described above were both scientific and feminist: to help students further explore and refine their learning about genetic inheritance; and to practice thinking into the future, about what it might be like to consider and participate in such a test personally, or vicariously, as an intimate other (e.g. a husband). In bringing these two goals together, I intended that students, by gaining a stronger grasp of the science, would in the future be able to interact with doctors and technicians with confidence and understanding. In a larger, sociopolitical sense, I hoped that students would explore and explicate their ideas concerning governmental and societal pressures in the areas of abortion and genetic screening, particularly in their capacity to control women's reproductive freedom to choose to or not choose to carry a pregnancy to term.

Connection and Alienation

As in the rest of this dissertation, my teacher-researcher goals were forefronted by my belief that students have plenty to say when they are given the opportunity. Thus, I listened for the connections that I predicted that students would make with the assignment and the material under study, prepared to hear signs of their interest in the processes of pregnancy and fetal development. I did not expect the girls' alienation from the topic that I have perceived through this research. I also did not expect the concern for the developing fetus, and in particular, a view of fetus as "baby" that I hear coming through loud and clear in the girls' discussions and presentations. Neither did I expect the abundance of student questions and stories based in their outside of school lives -- the media, neighbors', mothers' (but not fathers') and even their own direct experiences with prenatal testing and similar technologies.

My exploration of these students' interactions with each other and the assignment generated several overlapping themes. I provide support for these themes with excerpts from group work discussions in preparation for the presentations, and with excerpts from the presentations themselves. This analysis focuses on the female members of this class; boys' talk is only included when it is part of a transcript that includes girls. As you may recall, the membership of this course was made up of fourteen girls, three boys, and myself. Therefore this focus on girls was not difficult to attain. In addition, my focus here is consistent with the "female only" contexts chosen by difference feminists. Thus the analysis is *not* comparative between the girls and the boys; I am, again, centering on what the girls say. Thus I follow the example of Gilligan, Belenky *et al.*, and the other researchers mentioned earlier in this chapter, not in order to compare girls and boys, but to address the concerns, interests, and learning of the girls on their own terms.

The themes are named and summarized as follows:

Theme 1: *Knowledge of Pregnancy and Childbirt*h. These girls spent a great deal of time talking about other people's experiences with childbirth and babies. Their interest in babies and childbirth appeared more active than their interest in pregnancy, fetal development, or genetic testing.

Theme 2: *Pain and Safety.* These girls were concerned about pain and safety, apparently more for the fetus than for the pregnant woman. In this sense they grounded their work in physical experience, both actual and speculative.

Theme 3: *What's in a name?* These girls used the "everyday" language of pregnancy and fetal development instead of scientific terminology.

Knowledge of Pregnancy and Childbirth

Based in the perspectives and hypotheses of difference feminism, I had hoped that the prenatal testing assignment would particularly intrigue female students, because it concerned female bodies and pregnancy. In addition, I stressed the relationship aspects of prenatal testing by suggesting "roles" that recognized that the human contexts of prenatal testing and the issues it implies are often relational -- between couples, between women and doctors, between women and family members or friends. This dual approach was fruitful in developing a context within which to approach girls' thinking and connections (or lack thereof) to biomedical science. Its pedagogical success is, I believe, more tenuous and difficult to grasp.

I found that the girls took up this assignment both as a setting within which to discuss babies (those of others as well as their own potential children) as well as a place in which to demonstrate their distaste for the scientific representations of women's bodies and developing fetuses. An example of this is Tammy's confident statement made to her groupmates during their work on their presentation. The following excerpt also serves as an example of the girls' tendency to move quickly from the scientific aspects of prenatal testing to the context of babyhood and pregnancy. Tammy indicates a kind of knowledge that is not normally valued in science class. She knows something about infant development -- specifically, about visual development -- and has picked up on a recommendation for taking advantage of this knowledge in parenting.

Misti: We're gonna do ultrasound.
Tammy: Okay. Is that necessary though? Yeah, to check the baby's development (...) we'll do that then. Well, you don't really want, *I* would not want to know, personally (...) I would so I could like decorate their thing, you know --
Chantelle: Yeah.
Misti: I'm not gonna know --
Tammy: But don't make any pastels; make *dark colors*. (Delivered authoritatively as if she knows they will be surprised at this advice.) Reds, and --
Misti: (...) pastels.
Chantelle: I like pastels.
Tammy: Pastels make, when they make, when like they're developing, they can see like the primary colors --
Chantelle: (To teacher) Babies can't see pastels, dark colors?

(May 12: Group work in preparation for presentation.)

Carolyn came to me before class one day with a question about an infant who had died. While her connection to class work is not specific, it came during the time that we were studying prenatal tests. The condition that she is asking about -- "water on the brain" -- is one that we did not address during our study. However, I believe that our context of study (prenatal testing) encouraged her to come to me with this story.

Carolyn: (To me privately before class.) I have a question. What is water on the brain? I don't understand that.
Teacher: That's when water builds up between, it's either between the brain and the membrane that surrounds the brain, sort of holds it in place?
Carolyn: Umhm.
Teacher: Between that membrane and the (...) water builds up and there's pressure.
Carolyn: Cuz my sister's talking about it cuz her boyfriend's cousin had a baby and he had "water on the brain." She was saying that he didn't move at all. She just held him. I didn't know what it was.
Teacher: So are they able to do anything about it?
Carolyn: No. He died and they had a funeral.

(May 15: Private discussion with teacher.)

Tammy indicates her experiential knowledge of infants in the following excerpt. Her question is directly about fetal development, but she uses my (uncertain) explanation to develop an explanation of her own concerning infant behavior.

Tammy: This...has to do with like babies and stuff. Um, do they, okay, when they're just hooked up the umbilical cord, okay, do they go to the bathroom through that?
Teacher: They get rid of their wastes that way.
Tammy: How?
Teacher: Um, their excretory system isn't working yet, so the wastes that are produced are passed into the blood stream and out through the umbilical cord.
Tammy: So it's not like they form poop (...).
Teacher: (In a tentative speculative voice.) I, I don't know, because certainly by the time they're born they're able to do that, so I think probably later in the pregnancy they probably can.
Tammy: So latter on there's like, so they like poop in the placenta?
Teacher: I would think so; I don't know, I've never asked that question before.
(Some indecipherable comments from students.)
Tammy: That's why babies can stand like sitting in a diaper, forever until they like (...)
.
(May 18: Whole class review discussion.)

Two students referred to a gendered knowledge base, recognizing that "the guys" might not possess this kind of knowledge.

Linda: And ultrasound is really (...) and like almost everybody in here probably knows what an ultrasound is.
Girl Student: The guys might not.

(May 15: Presentations.)

The context of prenatal testing inspired questions and stories that would not have arisen if we had stuck to a more traditional mode of study for genetic inheritance. Nonetheless, while the girls claimed expertise and evinced interest in pregnancy and childbirth, they did *not* positively relate to traditional scientific representations of pregnancy and childbirth. They tended to alternate between disgust and caring affection for the "baby" or developing fetus. Their talk around the *science* of fetal development and of prenatal testing included overwhelmingly -- although not totally -- negative expressions of their perceptions of the fetus. In the first excerpt, students are describing the fetal villi as represented in a video they saw in health class. In the second excerpt, different students are looking through a college graduate level text for information for their presentation.

Carolyn: No, maybe, no, that was in health.
Belinda: Yeah, that was in health class.

Nicole: Yeah, they have those little fingers or something --
All: Yeah. Umhm. Right.
Elaine: Little what?
Nicole: -- they're like little hairs. Like the babies, they have hairs on their whole body, or something like that?
Carolyn: And like it falls off.
Elaine: Oh, okay.
Belinda: I don't know, I don't know if --
Carolyn: It falls off, and like the skin goes with it, the skin --
Nicole: They help the baby breathe or something like that.
Carolyn: Yeah it goes into their lungs and something like that? I thought it was gross!
Belinda: (Quietly) I thought it was cute.

(May 12: Group work in preparation for presentations.)

Tammy: Okay -- Ew!! Ew, look at this picture. That's the uterus right there. That's the embryo. I don't think soooo! Prenatal period, okay (...) Cleavage, we don't want to know about that. Don't even want to know -- how about (...) my notes (...) I don't care.
Chantelle: How come this side's growing faster than this side?
Misti: Come on, Tam.
Tammy: I'm looking for like tests and stuff -- oh look it. I don't care how it's developed --
Chantelle: It looks absolutely disgusting.
Tammy: -- it looks like a big blob.
Chantelle: Tammy! (laughter)
Tammy: I just want to find out what tests you can do on it.
Chantelle: Oooh, look at it, ooohhh --
Tammy: It's nasty.
Chantelle: -- it look's like a kangaroo!
Tammy: Uh-unh.
Chantelle: Yeah, the kangaroo fetuses.
Misti: Won't they do it when they know that amniocentesis --
Tammy: Ew, look it! It looks like an alien.

(May 12: Group work in preparation for presentations.)

These excerpts exemplify a kind of "alienation" from the visions of fetal development with which these students are interacting. They describe the fetus is "gross" and "nasty"; it even "looks like an alien." Belinda is the odd person out, in the sense that she perceives the video fetus as "cute." (As demonstrated under Theme 3, however, this view connects to more "baby-oriented" perceptions of fetal development.) And Tammy, who here says, "I just wanna find out what tests you can do on it," as her group is trying to decide what test to study, says of amniocentesis, "No, cuz the baby could die doing that; I don't want to do that." Nonetheless, the transcript indicates that Carolyn, Belinda, and

Nicole appear to have developed an understanding of the fetal ability to obtain oxygen from its mother. While Misti repeatedly attempted to get Chantelle and Tammy back to the assignment, her efforts were temporarily overwhelmed by the other girls' focus on the unfamiliar presentations of a developing fetus.

In the excerpt below, Lily, Nina, and Becky are presenting their findings on amniocentesis to the class. Lily is reading throughout the presentation from a two-page set of notes densely covered with words; the scientific vocabulary she uses is extensive, and she stumbles over the complex syllables. In this context of deviations from the norms of development, Lily represents a kind of alienation from the science of fetal development. This alienation is evident to me in two ways, the first of which is her apparent disconnection from the unfamiliar scientific vocabulary she is reading to the class. In addition, she becomes silly, which appears inappropriate when she is explaining the quite awful condition of fetal anencephaly. Nina is playing the mother; Becky is the father, and Lily is the doctor.

Nina: Hello. We're here for our appointment.
Lily: Oh yes. I'd like to talk to you about something. I need to um, we need to do a test called "amniocentesis."
Nina: What's that?
Lily: Well, um, let me give you a little background on this. It was developed in the 1960s. First as a test for Rh incapability. (She's a little slow on this word -- laughter from audience. I question class on Rh compatibility.). This is how it happens. Let me just -- (Lily puts overhead on projector and turns it on. Students chuckle.) A needle is inserted through the mother's body wall, and uterus, and it draws about 10 to 20 millimeters (*sic*) of fluid.
Students: Oooh.
Lily: (Reading.) This procedural *(sic)* does not require hospitaliza-za-za, hospitalization; it will be done in the clinic. Now, a test for Down syndrome, neural, let me start again, Down syndrome, neural tube closure defects, anencephaly, and spina bifida. (Some difficulty with these words. Laughter from class.)
Becky: All right. I'm fainting. (Fake faints.)
Lily: Okaaay. The amniotic fluid contains fetal secretions and living epidermal something cells from the respiratory and digestive tracts. Karyotypic analysis are done on the cells. Over a hundred single gene defects can be i-i-identified. What happens is when we stick that needle in there, we just take out some of the fluid in there, and then we grow cells, and then we, we, we grow them --
Tammy: No, wait. Do you grow 'em? (Laughter)
Lily: We grow them, yes.
Nina: Why do you grow them?

Lily: We grow them so we can ah make a karyotype out of the cells and we can detect (...) Down Syndrome; there're about 5000 cases a year; and this is identified by an extra chromosome; an extra 21 chromosome. Neural tube closure defects: 6000-8000 cases yearly. And this is detected by the presence of elevated levels of -- oh boy! (jokingly) -- alphafetoprotein.
Teacher: Often known as AFP.
Lily: Often known as AFP. In the amniotic fluid. Now anencephaly is absence of brain or spinal cord. And spina bifida is an open spine due to failure of normal closure of the spinal cord during embryonic development.
Becky: Will this harm our chances of having another kid?
Lily: Becky, you shouldn't ask that. (Laughter.) It won't, it won't, it won't harm your chances of having another kid. (She looks back at me.)
Teacher: You mean the actual test?
Lily or Becky: Sure. Whatever you've got.
Lily: But it does result, um sometimes it does result in spontaneous abortion, or, and if you do this too late in the pregnancy, then when the test results come back you will not be able to have an abortion if the child is not having a brain. (Quiet giggles.)

(May 15: Presentations.)

Lily's delivery throughout the presentation of this scientific terminology was light-hearted; she smiled regularly, and good-naturedly joked along with her audience as they quizzed her. For example, the interchange between Tammy and Lily concerning the growing of cells was not merely clarification; it was funny. Humorously diverting from her notes, which included a definition of anencephaly, Lily stated, "If you do this too late in the pregnancy, then when the test results come back you will not be able to have an abortion if the child is not having a brain." This statement resulted in laughter from the class, which apparently encouraged Lily to continue her joking throughout the rest of the presentation, including her response to Nina's question above. Nonetheless, this group had, as part of its presentation, an overhead transparency with a colorful drawing of a uterus surrounding a smiling and very aware-looking humanoid -- definitely more chubby baby than three-month old embryo -- with a cartoon balloon "hello" emanating from within the uterus (see Figure 5).

The girls, as indicated above, tended to move easily back and forth between the "science" and their own visions and knowledge of fetal development and pregnancy. The real life contexts are there; the science is there -- but the two are not meshing often or powerfully. They did not bring any "real life" stories, or outside-of-school knowledge,

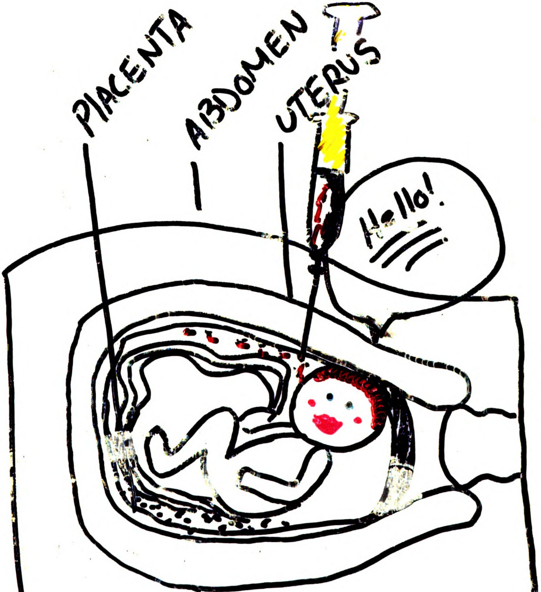

Figure 5 - Baby in Utero, Students' Drawing

into their presentation. Becky does ask, "Will this harm our chances of having another child?" -- a question indicating the use of a hypothetical "real life" situation; this is an example of students "thinking into the future," which was one of my pedagogical goals. However, their extensive use of scientific vocabulary overwhelms any stories or questions from experiences of self or others. Thus the science and "real life" remain disjoint areas of study and concern.

Stories and Connection

These students indicated much stronger and less ambivalent interest in pregnancy, childbirth and prenatal testing events and issues encountered in media and experiences *outside of* school. They told stories and shared knowledge in their small groups and during whole class discussion about fictional and actual representations of pregnancy and childbirth, including the pregnancies, labors and babies of neighbors and friends. References to videos, television shows and movies were plentiful. On separate occasions, students mentioned and described an incident portrayed on "Rescue 911," a birth on the Learning Channel, a video in health class about fetal development, and the movie "Lorenzo's Oil" (the story of a parents' quest for a cure for their son born with ALD[15]).

These and other apparently irrepressible connections that the very mention of pregnancy, childbirth and babies brought up for these female students dominate the data. Kari's and Chantelle's stories are typical of the ways that girls brought accounts of other women's real-life experiences -- as distinct from media representations -- into this curriculum.

> **Kari**: Um, the lady that lives across the street from me? She has three kids, and she had, she didn't have one for a long time, and then she had one when she was older, and she had to go get a test done on that, to see that it was okay, cuz she was older.
> **Teacher**: Umhm. Yeah. Right. Um, they don't force you to take any tests, but um yeah. Often women that are older like to have those tests. And everything was okay?
> **Kari**: Yeah. She, she had the baby. It's fine.

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[15]Adrenoleukodystrophy, a severe disease which affects the nervous system. The gene for ALD is carried on the X chromosome; therefore boys are much more likely to be born with it than are girls.

(May 18: Whole group review discussion.)

Chantelle: Well, concerning number 1[16], like, also, my mom told me an (...). Her babies were like all (...) and if she had had it (...) and her family has given her a lot of hard times and she (...) this baby, but she um kept it and it turned out that the you know the doctors made a mistake. (Someone says something about "suing the doctors.") And it came out fine. It's perfect. (...)

(May 18: Whole group review discussion.)

I follow with an extended excerpt from Linda's and Jessy's presentation on ultrasound. The presenters and two audience members (Misti and Tammy) are engaged in a discussion concerning the accuracy of determining fetal biological sex utilizing ultrasound. Misti and Tammy were themselves preparing to present their own groups' learning on ultrasound, and perhaps therefore especially keyed into Linda's and Jessy's talk. Early in this excerpt, the four girls are discussing the probability of the correct interpretation of the ultrasound images; from this, they move into another *actual* situation. This move and the talk surrounding it indicated two things: first, the power of stories from outside-of-school life as a basis from which girls can become engaged with science; and second, these girls' understanding of the uncertainty of the predictive power of prenatal visions via ultrasound imaging. The presenters here are Linda and Jessy; the other speakers are members of the audience.

Linda: And it's, they sometimes can determine the sex of the child through this (i.e., ultrasound).
Jessy: Sometimes. Not always.
Misti: Isn't that more most of the time, like 95% of the time?
Linda: That they can what?
Misti: Determine the sex. I mean if --
Linda: Well no because it can be wrong because um --
Misti: Well how often are they wrong?
Linda: Sometimes they are, they --
Misti: Yeah, but how often?
Linda: I don't know. There's, I don't know, I don't think there's any --
Tammy: They're not allowed --
Teacher: You people are so statistically...
Linda: (...) a fifty:fifty percent chance, probably. Because you can't always, I don't know. I don't know. (...) the umbilical cord (...).

---

[16]"A fetus should be aborted if by medical tests in the first trimester (3 months) of pregnancy it is shown to be severely genetically defective (the child would die prior to its fourth birthday)."

Teacher: (...) What would you do Lily, or one of these two people, if the umbilical cord was, for example, wrapped around the baby's neck? What could you do about that?
Linda: They would probably, make, do a caesarean instead of delivery the baby like normal. So. (...) Yes Tammy?
Tammy: Um, when my neighbor had her babies, she had twins, and the doctors were not, they told her they were not allowed to tell you if they can't just say "oh it's a boy, oh it's a girl" because they could be wrong. And they've gotten sued for that. So they're only allowed to say like "there's, you know, we think it's a boy, we think it's a girl, we're almost positive." So they're not allowed to say that.
Linda: Sometimes they can, they know for sure if it's a boy or a girl.
Misti: They still could be wrong though.
Linda: Yeah, unless, if they say it's a girl, they usually know for a fact.

(May 15: Presentation.)

Initially, I was disturbed by this continual storytelling, because I wanted the girls' focus to be on the science, not on stories of personal experience. I now believe that the girls' sharing of their out-of-school knowledge is saying something important to feminist science teaching. Traditional science content is disembodied -- and therein lies its generalizability. Feminist pedagogy, in its focus on the personal and particular, concerns itself with questioning content at its core, and stresses connections between lives, knowledge, and sociopolitical structures. As indicated in the previous excerpt, the girls were beginning to question the infallibility of medical technology. They are also utilizing their understanding of probability, an important concept in the study of genetics, to discuss the interpretation of prenatal tests. In this context they are combining their "real life" knowledge with their learning about the technology of prenatal testing. This situation provided me with one of several missed opportunities to push their critique into a realm that included the *science itself*, as represented in this study that connects directly to women's lives.

In reference to more mainstream recommendations, science education standards stress connections to the real world and to students' everyday lives and experiences. As these students relay their anecdotal evidence, the complications of the applications of prenatal technology are brought forth. The uncertainty of real life and the uncertainty of science and technology meld. Something that I always want students to do -- question the efficacy and unquestionability of science and its attendant technologies -- is indicated here; and the students are doing it, without prompting from me.

Pain and Safety

A continual topic of discussion during this unit was the question of the fetus's safety. A secondary issue, one that I found myself bringing up more and more as I noticed its absence in student talk, was that of the pregnant woman's comfort and safety. The only person other than I who mentioned the existence of someone other than the fetus was Chantelle, who had had direct experience with ultrasound. Chantelle's story was told quietly, to her two groupmates; she was generally silent during whole class discussion, and did not bring up her pertinent experience in front of all of her classmates. Her account brought to my attention the absence of the experiences of the actual people involved in these types of tests -- presented as they were in technological and scientific terms, it is easy, and neat, to set aside the possible discomfort and emotional consequences involved. However, as Chantelle had herself experienced such discomfort, she provided an unpleasant account of her encounter with ultrasound. It is also worth noting that, as in the previous excerpt, these girls are embedding questions about the technology in actual and potential physical experiences. Chantelle's own ultrasound, plus the imaginary endangered fetus, both provide peopled contexts for engagement with the technology.

The portions of transcript below come from group work in preparation for the role-playing presentation (May 12, Transcript). Chantelle, Misti, and Tammy are looking through reference books trying to decide which test they will study. (The numbers refer to pages that Tammy was finding in the index of the book she was using.) Chantelle made two attempts to interject her account into the small group's discussion; even when I was present, her success didn't come until the third try.

Chantelle: Amniocentesis is with the big needle, isn't it?
Tammy: 896. What's the question again? Oh, it was the next page. Duh. Okay. "A technique in which a sample of amniotic fluid is withdrawn (...) inserting a hollow needle through the mother's -- " Ew. No, cuz the baby could die doing that; I don't want to do that.

Misti: I've heard about that.
Teacher: Yeah, well, but the risks are pretty low, but there is a risk...
Misti: Yeah, but they could, if the baby moves or something.
Chantelle: Wouldn't that *hurt*?
Teacher: Well, why, what test can we use along with it, to help keep the baby safe?
Misti: Ultrasound. So, would they do both, they'd have the monitor on to watch the baby as they do it?
Teacher: Exactly.
Chantelle: That gel is so cold on ultrasound.
Misti: (Something about her mom.)
Tammy: How do you know, you've had it done? (...) Yeah, your kidney one, that's right.
Teacher: It's basically the same thing.
Chantelle: It was so cold, I flipped out.
Misti: Aaaack!
Tammy: Why is it so cold, though?
Chantelle: I don't know, it was just --
Teacher: Do you know why they use the gel?
Misti: Uh-hu.
Tammy: Because, um -- oh, oh, I know this, because my neighbor just went to get hers a couple months ago. Um, oh, they use if for something. It's, it's to help do sound waves, or something.
Teacher: The vibrations, I wonder?
Misti: Is that, do you know why?
Teacher: Pick up sound waves, maybe? (Everyone's talking at once here -- very difficult to decipher.)
Tammy: Yeah, it's to help to pick it up, I think, I don't know.
Misti: Would they still be able to do it without the gel?
Chantelle: I was so mad, she got it all over my clothes and everything.

(May 12: Group work in preparation for presentations.)

Becky and Misti both consider the mother's physical well being in the following. Becky combines the comfort of the mother with the "danger" to the "baby." Linda provides another instance of a girl demonstrating knowledge concerning childbirth.

Becky: Um, this, whatever --
Teacher: Chorionic. (We're discussing chorionic villus sampling.)
Becky: Yep. They, it's like faster, and, but it's but it's more painful (...) it's more dangerous to the baby.

(May 18: Whole group review discussion.)

Misti: Somebody I just know, she had a baby on Sunday, and she had one of them things you know where they stick the needle in your back, or in your spine?
Teacher: Spinal.
Girl Student: Spinal tap?
Teacher: Not a spinal tap. It's just called a spinal, it deadens all the nerves --
Misti: Okay, but she called it something else.

Linda: Yeah, I know what she's talking about (...).

(May 15: Presentations.)

Much more common than the feelings or well-being of the conscious adult were references to the *fetus'* subjective physical experience of pain or danger. In the longer piece above, as well as in the following excerpts, students focus on the experience of the fetus. Below, they are discussing amniocentesis.

Misti: Aaauh. (Sad cute sound -- like "oh poor little thing.")
Teacher: They don't touch the baby. They just get those dead cells and then they get the baby's chromosomes and then they make a karyotype. So what do they look for in the karyotypes to see if the baby has Down's syndrome?
Tammy: Something on chromosome 21?

(May 12: Group work in preparation for presentations.)

Nina (playing the pregnant woman): Isn't it possible, isn't it possible to like stab the baby?
Lily (playing the doctor): You're not supposed to ask any questions, Nina! (Said jokingly.)
Teacher: I think that's probably a pretty normal question for a mother to ask.

(May 15: Presentations.)

Misti: (O)n the Learning Channel they had a mother having a baby.
Teacher: Cool.
Misti: And, what happens if the child is having to move, like its leg, you know kick or something, when they're putting on --
Teacher: (..) Well, they're careful, and it's a skinny needle, and the baby --
Misti: Yeah but it's still --
Teacher: At that stage, okay? This is before three months, right? The baby's still pretty little.

(May 15: Presentations.)

What does it say that all of us regularly put the "baby" first, and rarely considered the mother? We seemed much more able to make the unborn fetus real than to make the pregnant woman's physical, emotional, and intelligent existence prominent. Prenatal testing can be seen in at least two ways, in terms of women's choice concerning pregnancy. There is an archaic and controlling vision of woman as incubator and little else; this vision puts the fetus' health and life before the woman's, and allows for legal and social constrictions on women's reproductive rights. Second is the potential that this kind of technology has for supporting women in making a choice to abort in the case that a fetus is not normatively healthy. I am unsure how important our focus on the baby/fetus instead of the mother was in influencing students' thinking about these issues; I am sure that I will address it directly with my students the next time I encounter it.

Among these students, while abortion was regularly mentioned during the presentations, it was not ever taken up as a topic of discussion. It seemed to go underground, most likely with my collaboration. In abortion's place as a "reason" for a woman to have a prenatal test was put the importance of preparation for a difficult child. This is not to say that students were anti-abortion. It is to say that abortion was never used as a reason to consider prenatal testing -- except for once, as Carolyn's group had the floor, explaining amniocentesis as a test for ALD. Here Carolyn is responding to my question "Would you recommend that a woman have this test?"

> **Carolyn**: I think, in my opinion, I would want to have the test done, because, it explains that it's a long, it's a stressful process to treat it, and I mean, if I were pregnant with a baby who had um ALD then I wouldn't really want to bring that child into the world. I mean not to sound cruel or anything because I think it would be better to not bring him into the world than to bring it into the world under a lot of pain. That's just my opinion.
> **Teacher**: Thank you.
> **Carolyn**: And I think women should have this test done because they would know ahead of time, before the child was born.
>
> (May 17: Presentations.)

As Carolyn remarked directly before this transcript segment, prenatal tests increase the chance of spontaneous abortion (miscarriage). As the students studied and presented their information about the test they chose for the assignment, the phrase "spontaneous abortion" consistently came up as a "danger" of each kind of test. This danger is one that certainly involves both mother and fetus. Nonetheless, there was a marked tendency on both the students' and my part to focus our attention on "the baby" -- its comfort, safety and successful journey through development and birth. As Barbara Katz Rothman puts it, "[F]etuses...have been made 'real' for us by science....And people who have never been pregnant, never shared anyone's pregnancy intimately, can visualize the fetal head shape, fetal hands, fetal movement in utero" (1989, p. 115). Teaching a topic as abstract as chromosomal inheritance, it is not easy to engage students in "real life" experiments. The observation that people in our society, including students, have seen many representations of fetal development is something that I want to take advantage of, although it continues to disturb me that the pregnant woman responsible for the fetus' existence is not in the forefront of these discussions.

In addition to Carolyn's statement above, there was an incident in which a female student expressed her right, as a woman, to understand what was being discussed concerning her body. In this bit of transcript, Kari is the pregnant woman, Alex is her husband, Jonathan is her brother, and Sam is the doctor. Kari was the only girl in her group, composed of herself and three boys. The test they are discussing is chorionic villus sampling. Alex is an actor; he participated regularly in school musicals, to popular acclaim. In this presentation, he adopted a German accent, and "fainted" upon hearing a description of the sampling procedure. The tone of this group's presentation was one of humor supported by good-natured kidding from the audience.

Alex: So how long does this all take?
Jonathan: (sotto voce) And when should you do it?
Alex: And when should you do it?
Sam: Eight to ten weeks after life begins. Or conception. Whichever you prefer.
Kari: All right, before we get any further, and you guys are talking about *my* body --
Alex: Hold on --
Kari: -- no, I want to say this.
Sam: You get the results in 7 to 9 days.
Kari: What are the dangers of me doing this? You doing this test on me?
Sam: The dangers are spontaneous abortion.
Kari: Okay! (laughter)
Girl student: Spontaneous?
Alex: How often does that happen, do you know? Maybe I shouldn't ask that. Doctor doesn't know. (Laughter) Never mind.
Jonathan: Oh and the --
Sam: It happens more than amniocentesis, but it's still not all that often.
Jonathan: Okay. And ah would, would you recommend her having this test?
Sam: I'd only rec --
Jonathan: When do you think it would be appropriate to do, for her to have this test?

> **Sam**: I'd only recommend this test if there was a past history of genetic disorders. If not, amniocentesis would be (...). (Audience begins clapping.)
>
> (May 15: Presentations.)

Kari's statement, "[Y]ou guys are talking about *my* body," was of the type that I was hoping to hear from more students. However, after her bid to focus the discussion on *her* well-being, she again faded into the background as the "men" took over the discussion. Kari is not only interrupted, but quickly gives up her temporarily assertive stance, when she is told that the possible danger to her is "spontaneous abortion"! The picture of the male doctor, husband, and brother discussing the pregnant woman's (Kari's) fate was rather disturbing and, for me, emblematic of the important feminist issue of reproductive control.

<u>What's in a Name?</u>

I surveyed transcript from this prenatal testing unit, specifically: 15 minutes each of two groups preparing their presentations; 55 minutes of group presentations (which included questions and comments from teacher and students in the audience); and 35 minutes of whole group discussion concerning prenatal testing. This forms a substantial portion of the talk during our study of prenatal testing. The sample contained 10 uses of the words "fetal" or "fetus"; 1 of embryo, and 1 of embryonic; and *82* of "baby." "Baby" was used regularly, by students and by me, to refer to what is more properly named the "embryo" (three months since conception) or the "fetus" (three months through nine months into pregnancy).

In all of the transcripts I have of this unit, only two girls, unprompted, used the scientifically accurate words "fetus" and "embryo" (see Tammy above, and Lily during her group's presentation). As demonstrated in this excerpt, and many places throughout the data, I colluded in this decidedly unscientific talk.

> **Teacher**: Try not to laugh too hard at my drawing, okay? This is a uterus, okay? (I draw on board.)
> **Misti**: Nice drawing, all right!
> **Teacher**: And we've got the little growing baby here --

Students: (mild laughter, comments -- e.g. "It looks like a mushroom!")
Teacher: Okay. And then, the placenta, as you know, lines the uterus, right, this nice rich blood supply, where the oxygen and the food and the waste pass back and forth between the mom and the baby. Um, this thing, it's called a chorion, it's a membrane that's attached to the baby.

(May 15: Presentations.)

Misti: What test do you use to find out if the baby has Down syndrome?
Tammy: That's a genetic thing. That'd be, um, that'd be an amniocentesis, wouldn't that be?

(May 12: Group work in preparation for presentations.)

Linda: Well, an ultrasound is when they send um sound waves (...). Like where the baby would be. And it reflects, it bounces off the baby, you know, gives a shape of the baby on a monitor.

(May 15: Presentations.)

Lost in the translation from scientific to everyday language are distance, objectivity, and clarity; gained in the translation are intimacy, complexity, and untidiness. This is a prevalent pedagogical issue: How and when should we allow unscientific vocabulary to be left unnoted? If it is true that we can help students connect with science by avoiding alienating scientific knowledge, what then? Should I have insisted that the students say "fetus" or "embryo"? Or did allowing them -- even encouraging them, by my own language -- to use the words of their choice allow them access to knowledge that may have been denied them if other words were utilized in our discussions? I also hoped to help them be intrigued throughout the unit, and thus hesitated to impose more scientific vocabulary on them. The overuse of scientific vocabulary succeeds in confusing and alienating more students than it intrigues. Nonetheless, I continue to wonder to what extent not insisting on scientific vocabulary may have deprived students of the opportunity to question their assumption that a "fetus" and a "baby" are identical beings..

This issue is problematic from a feminist viewpoint as well. Recognizing the fetus as "human" by calling it "baby" -- which it is, in scientific terms, called only *after* birth -- may have influenced these students to believe that abortion is murder. As a feminist, I hope that student-citizens will be "pro-choice." As a science teacher, I wonder if where they stand on abortion is any of my business. Particularly as I continued to communicate with students throughout this unit, I realized that the unavoidable differences between the teacher's politics and students' beliefs played a role in my ability to practice feminist pedagogy. I believe that feminist pedagogy is not hiding one's politics; I am also certain that it is not imposing one's beliefs on others. Certainly I hope that students learn and thus change, and much of that change I hope will concern social issues, particularly those that concern women and other oppressed groups. Nonetheless, I found it inappropriate to state that students were *wrong* in their beliefs.

Discussion: Two Models for Listening to Girls

There is a thin line between difference feminism and essentialism, and it is easy to trip over that line. Visions of women that are either stereotypical or essentialist place us within a scheme that shapes our lives as caring and relationally focused. Some researchers have found that girls and women express these characteristics as part of ourselves, and as affecting our interests (or lack thereof) in school subjects (Belenky *et al.*, 1986; Gilligan, 1982; Rosser, 1992; Roychoudberry *et al.*, 1993-94). I feel that a conflict arises here, one feminist theory and practice can illuminate, if not resolve. I am emphatically not implying that girls should not learn science, that they are well set with their planned role as mothers. I do want to say that the girls in this class during this time were able to speak with authority -- both because they did have a wide amount of experiential and anecdotal knowledge concerning pregnancy, childbirth, and children; because they have female bodies, and because, as my college student daughter reminded me, these topics are something that it is socially acceptable for women and the girls they grow into to be interested and knowledgeable about.

Difference feminists have found that girls and women regularly consider people other than themselves in their moral decision making. "Putting others first" is one way that this finding may be interpreted. It fits in well with a mythological model of women as selfsacrificing and other-centered, and helps to explain and maintain the roles of women as the primary nurturers in our society. This is something that I had hoped to help students challenge. I found myself, however, so well-versed in this psychological habit that I not only readily recognized it in my students, but expressed it often myself. I very likely encouraged the girls to see themselves in the role of nurturer, protecting a helpless being in the face of possible danger and pain. The live woman involved in the decision may have been assumed capable of taking care of herself -- as well as of the fetus (or baby) that they assigned to her care.

A more complex and less denigrating moral model is developed by theorists in difference feminism (Barbieri, 1995; Gilligan, 1982; Gilligan *et al.*, 1990). In this model, girls and women learn to consider *both* themselves and others in their thinking. This representation of "feminine" moral reasoning is more complicated than "either I suffer for your benefit, or I ignore you in favor of my own well-being." Girls and women learn to become adept at constructing views and decisions that consider all members involved. This is not to imply that females possess a magical ability to make everybody happy. They may agonize about the effects their own decisions will have on others and struggle to develop outcomes that hurt everyone as little as possible. The pertinent point for this chapter is that this model helped me to hear the girls availing themselves of multiple imaginary and actual perspectives -- those of themselves, of fetuses, of babies, and of women -- to think about issues that arise from the technology of prenatal testing.

Prenatal testing provides situations in which decision making based in personal, physical, and emotional relationships is central. The girls in this study demonstrated both of the models described above in their talk around prenatal testing. My initial impression was that they were totally ignoring the pregnant woman in their talk; this still remains a dominant theme. However, as I studied the data more carefully, and as students progressed through their work with prenatal testing, I noticed that the pregnant woman made at least an occasional appearance as a physical and emotional being (see Kari, Chantelle, Becky, and Misti, above).

I propose that topics such as prenatal testing, in which women are, at least in nonscientific life, considered "expert," allow for more connecting pathways for engagement with the content of science. As my daughter reminded me, pregnancy and childbirth are things that our society expects girls to be knowledgeable about. That doesn't mean that they are -- or that they care to be, particularly on an individual basis. But social expectations and personal behavior and knowledge interact, and the girls in this classroom demonstrated a strong sense of their own knowledge in this area and a broad collection of relational anecdotal evidence for their ideas and questions. Girls dominated in the talk during this unit; in turn, discussions of real-life experiences and anecdotes dominated the talk. Girls moved easily back and forth between science and real life. However, the focus was on actual experience -- and, when pertinent to the girls, the science was brought in as a way to understand its effect on those particular, physical and emotional lives.

Traditional, objective science is disembodied -- this, paradoxically, allows it to be used to control women's bodies through the forms of medical technology (Hubbard, 1990; Rich, 1986; Rothman, 1989). Medical science's ability to see inside a woman's body, and to make claims concerning the condition, sex, and genetic makeup of a developing fetus, has grown in efficacy and its use has grown in popularity within our adult lifetimes. The concerns that this technological development brings up are pertinent to people of all political persuasions. Even when we leave aside the personal and societal ramifications of this technology, the study of prenatal testing offers a rich focus for the study of chromosomal inheritance, the influence of the sex chromosomes on biological sex, and the causes and manifestations of a variety of genetic conditions.

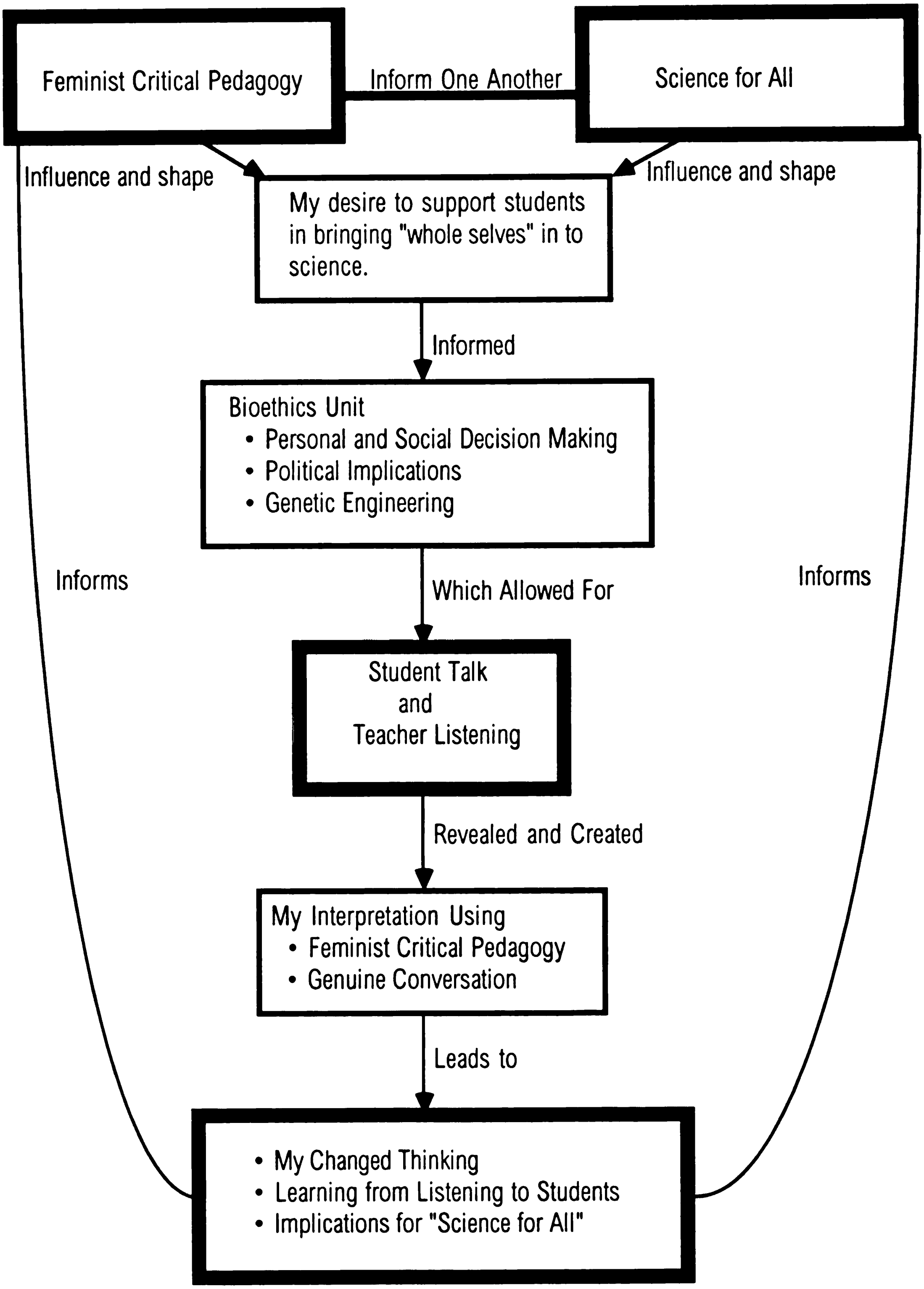

Figure 6 - Flow Chart Chapter VI

FEMINIST CRITICAL PEDAGOGY

[D]ialogue is much more difficult to foster than feminist educators (or the critical pedagogy fraternity) ever imagined. Perhaps we would do better to understand dialogue as the goal of pedagogy and not a condition for it.
Jane Kenway and Helen Modra (1992), p. 163.

Feminist teachers...attempt to counter the ways schools have traditionally reproduced patriarchal social relationships.
Kathleen Weiler (1988), p. 125.

Without paying particular attention to our specific practices of pedagogy...we might altogether overlook the ways in which pedagogy operates, and furthermore, the pedagogies for which we argue so earnestly and sincerely will remain inconsistent with the pedagogies of our arguments.
Jennifer Gore (1992), p. 157.

SCIENCE EDUCATION STANDARDS

If students are expected to apply ideas in novel situations, then they must practice them in novel situations.
AAAS (1990), p. 18.

It is important for students to understand how science is organized because, as adults in a democracy, they will be in a position to influence what public support will be provided for basic and applied science.
AAAS (1993), p. 14.

Because molecular biology will continue into the twenty-first century ...students should understand the chemical basis of life not only for its own sake, but because of the need to take informed positions on some of the practical and ethical implications of humankind's capacity to manipulate living organisms.
NRC (1996), p. 181.

Markers of Feminist Critical Pedagogy

• Issues of power and authority are upset and explicitly addressed. This includes notions of what valuable knowledge is, who creates it, and who has access to it.

• Students' experiences and feelings are valued, and count as "real knowledge."

• Class (political and socioeconomic) are analytical categories.

• Gender is a primary analytical perspective. Masculinist critical pedagogy has been critiqued by feminists -- e.g. Kathleen Weiler and Jennifer Gore -- for ignoring gender oppression.

• Conversation and discussion are vital pedagogical tools and learning activities.

• Conversation and shared knowledge lead to communal theory making *plus* action.

What are the conditions necessary?

- Teacher uncertainty
- Shared authority for knowledge
- Questioning authorities that usually aren't questioned (e.g. science)
- Shared goals
- Explicit politics

CHAPTER VI
FEMINIST CRITICAL PEDAGOGY, BIOETHICS, AND GENUINE CONVERSATION

In this chapter, I focus on the question: What might whole group classroom discussions that foster students' expressions of their beliefs, experiences, and feelings look and sound like? I study student talk in a way different from in the previous chapters, through the eyes and ears of the teacher and within the action of the classroom. The analysis focuses on the first day of a short bioethics unit. This lesson is rich in possibility for reflecting on the nature of student talk in science class and the role that the teacher and the topic can play in shaping its quality and range.

I have organized my analysis of student talk in this lesson using the concept of *genuine conversation*. I define genuine conversation as talk in which students and teacher exchange ideas as equals, deviating from the typical discussion structure in which students receive and teachers deliver information. This chapter is an explication of this mode of talk as I noticed its appearance, disappearance, and variations during a short segment of dialogue on the first day of this bioethics unit. Two themes have arisen the course of this analysis: 1) Genuine conversation allows for a kind of student talk that is rich and complex, combining students' beliefs, knowledge, experiences, and feelings. But this kind of rich talk can feel messy and almost chaotic, to the teacher. 2) The teacher plays a role in encouraging this kind of talk, by modeling uncertainty, sharing personal beliefs and the life experiences that have helped to shape these beliefs. It is also the topic itself that helps to create a context conducive to genuine conversation.

Genuine Conversation and Feminist Critical Pedagogy

I choose to use the somewhat awkward phrase "feminist critical pedagogy" because the pedagogy that I am most intrigued with includes politics, which are not always present in descriptions of feminist pedagogy. For me, pedagogy that is feminist needs to address issues of gender and power as they appear (and are hidden) in the classroom and in science. Often feminist pedagogy is seen as something that recognizes that boys and girls are different, that attempts to develop a comfortable learning environment for all, and that maybe even introduces the work of women into the curriculum. The critical piece may get left behind. Therefore, in this chapter, I want to lay out my vision of feminist *critical* pedagogy, which, for some, may be contained in the shorter phrase "feminist pedagogy." Feminist critical pedagogy includes the explicit discussion and development of political action. That is not to say that political action is what happened during this unit; only what I hoped would happen.

Feminist critical pedagogy has roots in two camps: Freirian liberatory critical pedagogy, and feminist consciousness raising practice. The former centers on the idea that oppression exists, that pedagogy can help students recognize their own oppression, and, importantly, do something about it. The latter focuses on combining the personal with the political via individual expression of experience in groups conducive to recognizing connections between personal experience and political action. Feminists have noted that *women's* experiences of oppression are not typically addressed by critical theorists (Gore, 1992, 1993; Weiler, 1988, 1991); therefore it is necessary to keep the lives of women as the focus when one's critical pedagogy is feminist. The common thread between critical pedagogy and feminist consciousness raising is the centrality of students' and participants' experiences and the knowledge that has arisen from such experiences.

Critical Pedagogy

Critical pedagogical philosophy is based in Marxist theory, which utilizes class as its primary analytical category. Paulo Freire, the founder of critical pedagogy, developed his theories working with peasants in Brazil under a military dictatorship. Due to his political pedagogical efforts to teach peasants to read -- and, in the process, to recognize their oppression and fight against it -- he spent years in jail, thus certainly "living" his pedagogy. Freire's open politicization of pedagogy departs drastically from a model in which the teacher transmits knowledge to compliant and ignorant learners. In fact, it is Freire's term "banking pedagogy" (Freire, 1970/1989) that describes this one way movement of knowledge, which has been not only critiqued from a political perspective, but also put into question by constructivist theorists of learning.

Freirian critical pedagogy is premised on the power of students' talk and experiences, with an expectation of dangerous, political activism. His vision of liberatory critical pedagogy places knowledge in the hands of the students, as they learn to "read the word and the world" (Freire, 1970/1989) through explication and discussion of their own lives. This political-epistemological partnership is a marker of feminist pedagogy as well (Weiler, 1991).

Feminist Consciousness Raising

Feminist consciousness raising grew out of women's activism during the 1960s Civil Rights movements in the United States. These groups consist of women who come together around shared goals -- goals that involve change in oppressive political, social and personal circumstances for women. Consciousness raising groups provide an egalitarian forum for women to share their own experiences and interpretations of the world with other women. Out of these sharings grow theory and action (Frye, 1992; Hartsock, 1979; Weiler, 1991). Pedagogy based in feminist consciousness raising challenges the power wielded by men in theorizing about women, women's behaviors, and women's roles.

In science, feminist consciousness raising groups can allow women to puzzle over our own problematic relationships with mainstream science (WISE Group at MSU, 1995). Although personal enlightenment is often a result of participation in feminist consciousness raising groups, they concomitantly serve as contexts for reading and study. Ideas external to the group provide additional frames for the analysis of personal experience. My own experience in such a group has convinced me of the power of learning in such situations. It has also supported me in my initial attempts to teach my own students about the political aspects of scientific knowledge and practice. Theory, experience, values, and feelings come together to provide the impetus and support for change that feminist consciousness raising engenders.

Feminist Critical Pedagogy

A central tenet of feminist critical pedagogy is that students are afforded opportunities to openly explore their experiences, feelings, and perspectives. Students may then be supported in connecting their current thinking to new ideas presented by the teacher, the readings and activities, and each other, thus honoring, but also developing, their own learning and lives. Feminist critical pedagogy, as I am envisioning it, consists in students "making theory" out of their own experiences, knowledge, and values. Thus the importance of students' ideas expands beyond finding out students' "prior knowledge" in order to shape their educational experiences, linearly, from there. Students' ideas and the words that they use to express them *become* curricular material, as or more important than any other.

Science assumes a dichotomy between self and knowledge, emotion and rationality, and the personal and the pedagogical (Hasbach, 1995). Feminist critical pedagogy aims to dissolve these dichotomies. Part of this imperative entails questioning the flow of authority from "expert scientist" through "science teacher" to "ignorant science students." Unlike traditional science teaching, feminist critical science teaching would explicitly base curriculum in students' experiences, feelings, and knowledge. This approach does not preclude introducing students to canonical scientific perspectives and explanatory concepts. However, by participating in discussion based in personal perspectives, enlarged by listening to others, students in feminist critical science classrooms would develop theory to describe and explain their world, rather than uncritically accepting theories from outside authorities. Thus feminist critical pedagogy recognizes students as experts in their own lives, and as in control of their own learning (Belenky *et al.*, 1986; Maher & Tetreault, 1994).

Both of these streams of radical pedagogical thought put a lot of energy into making talk central. Freire's work with peasants taught them to speak their way to literal and political literacy. Women in consciousness raising groups speak about their lives and find that they are not alone in experience and perception and, from there, take political and personal action. Feminist critical pedagogy deeply values what students bring to the learning context, and attempts to make the experiences and feelings of the students central to the curriculum.

My goal herein is to use feminist critical pedagogy's demand that students' experiences and feelings, revealed and valued via extensive discussion, are made central to the curriculum, with the end aim of political, social and personal action. I have come to view this as parallel with Freire's "reading the word and the world," in that I want to teach in such a manner that students learn the concepts and practices of science, while also learning the social and political embeddedness of science from feminist perspectives. This form of scientific literacy demands that we learn to create classroom contexts in which students' ideas are front and center -- and stay that way, throughout instruction.

Science Education and Feminist Critical Pedagogy

On the face of it, feminist critical pedagogy and standards for science education developed by mainstream national groups would appear to have little in common. Feminist critical pedagogy is based in personal experiences, feelings, and perspectives; while, by their very nature, "standards" are generalized recommendations for teaching practice and content inclusion. Feminist critical pedagogy is concerned with the betterment of the world for women; standards are concerned more with the advancement of science, and its appreciation, understanding, and practice by nonscientists as well as potential scientists. Feminist critical pedagogy questions and challenges claims to authoritative knowledge; the standards claim to represent authoritative knowledge.

One can find support for just about anything in the standards.[17] Just about anything -- but not for any form of feminist critical pedagogy as I understand it. No explicit mention of science and its relationships to political and social power. No explicit recommendations

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[17]As Michael W. Apple states in his critique of the national standards for mathematics education, standards documents "must have a penumbra of vagueness so that powerful groups or individuals who would otherwise disagree can fit under the umbrella" (1992, p. 413).

that students puzzle over the role of science in a democracy, or its role in the oppression of women. No explicit recommendation that teachers and their students challenge the authority of science, or include their own experiences, feelings and perspectives as vital, central foci of the curriculum. Certainly no mention of social revolution, which is, at its heart, what feminist critical pedagogy is grounded in. It appears, then, that feminist critical pedagogy and the national standards for K-12 science teaching remain fundamentally at odds.

The saving connection between the two is the powerful although tenuous thread of "science for all." Feminist critical pedagogy aims to educate students about the constricting and prejudicial constructions of gender, race, and class in our society. The standards' explicit call that *all Americans* learn to understand and appreciate science is in itself revolutionary. Science has been a bastion of elitism and male supremacist power. With this new stance that anyone can do science, and that science be presented as an egalitarian, democratic enterprise, typical paradigms of knowledge, authority and power are immediately open for debate.

And to return to a theme that permeates contemporary science education: Teachers need to know what students are thinking in order to teach them better. As in all of this dissertation, the goal of hearing students' ideas is one that I put in the forefront. In this chapter, I examine the role of "genuine conversation" in allowing students to express their thinking, and in encouraging the teacher to listen honestly and attentively.

My Thinking as a Teacher

Feminist critical pedagogy has been developed with adult students and participants; adults who come together around shared issues, and who have a common set of experiences and feelings because they come from common class, race, and gender backgrounds. No such commonality exists in a high-school classroom. Neither, of course, does student choice in terms of school, content, teacher, politics, or action. So, without disregarding this powerful pedagogy because it seems too removed from the typical science classroom, how can I explore its power in developing a classroom in which kids can "read the word and the world," in science class, no less?

I have always thought that student talk was important. In the beginning of my learning to teach, I envisioned impassioned and articulate discussions carried out by students, inspired by my own well-chosen and inspiring comments and questions. I saw myself standing off to the side, with a wise and quiet smile on my face; arms crossed, prepared to insert brief, powerful insights into the students' talk and lives. As I struggled to learn "management" -- and I think that I may well have struggled longer than some, *because* I so valued student talk, and feared shutting it down[18] -- I recognized that it wasn't that easy, smooth or automatic. While I continued to believe that part of my role as a teacher was to guide classroom talk, I began to notice and examine the troublesome distinction between guiding and controlling. As this chapter indicates, I was encountering a tension between student freedom and my responsibility to their learning. I knew that some teachers could skillfully pick up on certain comments and questions, thus leading students to the conclusions that the teacher desired. I knew that I wasn't very good at this; I also knew that when I felt myself trying to do it I got very nervous, feeling an authoritarianism thinly disguised as responsibility to the students and to the discipline creeping up on me.

This remains an issue that I am unable to resolve. However, I have come to believe that *genuine conversation* [19] is a useful context within which students can freely and comfortably express themselves around difficult issues. My role, as a facilitator of students' expressions of belief, included modeling such expressions myself. Going into teaching this unit, I was solidly cognizant of the fact that I didn't want students to put down each other's ideas; I tried very hard not to do so myself. This, in hindsight, has brought up

[18]I owe this insight to my work with secondary science interns, particularly those who value students' talk.
[19]See Christopher M. Clark (1997) for a thorough discussion of "authentic conversation." My description of genuine conversation has much in common with his of authentic conversation. I have no doubt that my conversations with him over the last eight years, and particularly during the time this chapter was written, have greatly informed my own description (although I did not read his description until *after* I wrote this chapter!)

a feminist dilemma: When is expressing one's own thinking and beliefs honestly called for as a way to support and/or challenge students' thinking and beliefs? This dilemma may be one endemic to feminist pedagogy because it stresses the engagement of the personal and the need to create curriculum out of students' lives and knowledge, resulting in a focus on student-centered, student-created discussion. In fact, I came to the conversation examined in this study through the *surprise* that I felt when I noticed the curiosity students evinced at my work in the laboratory. This situation intrigued me also because it reminded me of the discussion around the edges of the literature on feminist pedagogy (Barton, 1995; Beck, 1983; Hasbach, 1995; hooks, 1994; Rosenthal, 1994, 1995) concerning the role of "teacher self-disclosure" in teaching. This chapter begins as an examination of what happened when I shared my own beliefs, particularly the role this sharing played in encouraging students to speak their minds.

Genuine Conversation

The Instructional Context Becomes a Research Context

During the springtime unit that provides the focus of this chapter, these high-school sophomores and I worked with the bioethical and scientific issues around genetic engineering. We had been together since January; this being late May, I believed that we were fairly comfortable and relaxed as a "learning community." During this study of biomedical advances and the ethical challenges they bring forth for individuals and groups, these students demonstrated to me, as never before, their ability to engage with the provocative and complex issues that arise in the interface of genetics, social and personal expectations, individual choice, and intimate relationships.

This unit consisted of a set of activities initially developed by a university[20] curriculum concern, and tested and adapted by Barbara Neureither. While I, and my students, put our own stamp on it, I utilized these materials mostly unchanged. Included in this curriculum was a list of controversial statements concerning the present and future

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[20]Ball State University, Muncie, Indiana.

choices that individuals and our society are being required to make due to the success of molecular biology and its attendant technologies. This list is referred to as "the survey" in my analysis. "The Hammer Exercise" also came from this source; it is explained below. In the course of the unit the students developed a "Personal Reference Sheet" to guide them through decisions concerning bioethics; they also worked with case studies concerning bioethical issues. When we formally left the unit, we commenced a study of genetic engineering. During this latter unit, I continued to ask students to refer to ethical considerations in their study of potential creations and applications allowed by genetic engineering.

This unit of study provided us with a meaningful context within which to deviate from traditional science teaching and learning. Both because bioethics itself is a field rife with overlapping concerns -- scientific, personal, moral, legal, and political -- and because ethics are considered a matter of personal choice, we were able to cross the lines that normally separate the scientific and the personal. Dichotomies were defied or ignored; emotion and intellect merged; the teacher and the taught become less distinguishable. This dichotomy-ditching was particularly notable during the whole group discussion segments that I have classified as "genuine conversation."

In this chapter, I study only the first day of this bioethics unit. I chose this day to include in this dissertation because it provides an example of a context that welcomes students' beliefs. Chapter IV arose from work that I did with students greatly outside of class time; Chapter V was developed from hours of listening to audio- and videotaped records of student talk. I realize that this kind of in-depth and time-consuming research is difficult for most full-time practicing teachers to arrange. This chapter, however, is focused on a few minutes of classroom discussion. Therefore I hope that it may provide not only a model for instruction that elicits students' beliefs in science class, but as a model of research that might be more attainable for already overworked teachers. In terms of instruction, the teacher can find out a lot about her students' beliefs if the proper context and atmosphere are encouraged. In terms of research, one encounters an infinitude of information, questions, and insights from listening to a mere five minutes of complex classroom talk!

I also chose this first lesson for intensive reflective study because it was not a comfortable teaching experience. Two reasons for my uneasiness stand out now. First, I did not do as good a job as I would have liked in supporting students in sharing their ideas. I believe that I was taken aback by the excitement and intensity that these issues brought from them; I was not prepared to support these. Instead I "stuck to my plan," pushing forward into an imaginary time where I thought that I *would* be prepared for listening to students' strongly held personal beliefs about controversial issues. Second, as I have come to realize through writing this chapter, the *topic itself* lends itself to an uneasiness that is not easily managed in the context of traditional science teaching. What I had hoped would be a "comfortable learning environment" for all -- especially myself! -- turned out to be one that threatened to slip away from my control. The excitement and emotion that quickly permeated our not-so-comfortable learning community dispensed with traditional science content and disallowed traditional discussion patterns to continue. Now I am glad. Then I was nervous. I will return to this issue in the summary.

Beginning the Bioethics Unit

The first lesson in this bioethics unit was complex. It involved three distinct activities, interspersed with discussion, both planned and unplanned. I have created a "timeline" to assist the reader in accompanying me as I negotiate a piece of the rough waters of this lesson. Each of the three main activities are described below, as we encounter them in sequence. The activities were:

1. Rating the statements on the survey: Getting the conversation about bioethical issues going.

2. The Hammer Exercise: Making decisions about which forms of living things it's acceptable for people to kill.

3. Introduction of Personal Reference Sheet: Beginning to develop a decision making model for bioethical issues.

Please refer to the time line, which indicates the times and the order of "Lesson Segments A, B, and C" and the placement of these activities within the lesson. Each activity under discussion is described below. The lesson segments that I am using here come from the first day of the bioethics unit. I chose these segments of dialogue because I was surprised at the students' interest in my work in a biological research laboratory. Studying the discussion in more detail, I noticed that I said things about my own experiences and feelings, particularly my uncertainty in the face of bioethical decision making. I began to wonder what role my talk may have played in the students' eagerness during this lesson to explicate their own beliefs, in concert with and in opposition to those of their classmates and teacher. The three subsegments of dialogue under study represent my comprehension of the role that certain statements and moves of mine may have played in setting up a context in which students were free to admit and proclaim uncertainty and disagreement. The remainder of the lesson contains fascinating student talk that I will discuss in upcoming work (Howes, 1997).

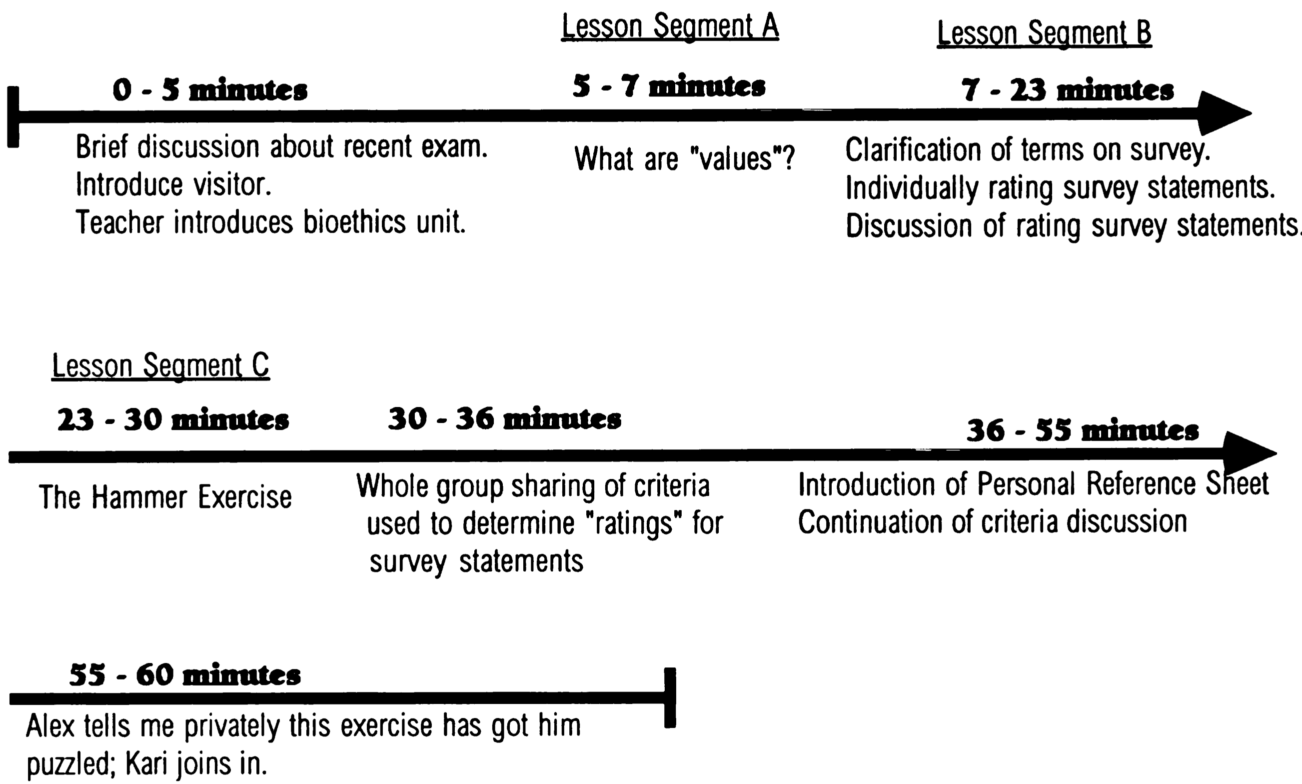

Figure 7 - Timeline for Lesson 1 of Bioethics Unit

Lesson Segment A: Typical Classroom Talk

As part of the introduction to the bioethics unit, the students and I spent some time clarifying our understanding of the word "values." I thought that it was important to do this because I considered "values" a central issue in the bioethics unit. The following talk takes a common classroom form, as students respond to a teacher-initiated question. The students spoke one at a time as I called on them. I accepted multiple explanations and examples from students. I also repeated and elaborated on students' responses, maintaining my teacherly role as arbiter of ideas. I did not ask students to expand on their statements, although I tried to get Jonathan to speak in language his classmates could comprehend. And I did not expect or encourage students to interact verbally with each other. I stopped this discussion and moved on when I felt that a few students had provided definitions that were close enough to what I was thinking.

Elaine: What are, what are "values?" Misti?
Misti: Nothin'. Somethin' like -- I don't know.
Girl S: Cherish.
Girl S2: Yeah. Somethin' like that.
Misti: Somethin' that's important to you.
Elaine: Okay. Some thing that's important to you, and, Jonathan?
Jonathan: Your metaphysical way that you deal with society (...).
Elaine: Okay (smile in my voice), your metaphysical way you deal with society? Can you say that differently? (He's talking at the same time.)
Alex?: Now seriously.
Jonathan: (...) It's like the concepts, or the things that you base all your decisions around, that helps you make your decisions, that guides your decisions...
Elaine: Um, okay, things you base your decisions on --
Jonathan: Yeah.
Elaine: -- guide your decisions?
Jonathan: So that means like it's instead of decisions you make that guide you (...)
Elaine: Okay. Kari?
Kari: Something you think is like worth something to you.
Elaine: Okay. Good.
Kari: (...)
Elaine: Like if you value doing your homework, you'll spend a lot of time on it. If you value being outside, you will be outside on a beautiful day. Maybe if you value both, you'll go do your homework outside, right? Becky?
Becky: What you believe in?
Elaine: Okay. All right. So.

This interchange about "values" is one example of typical classroom talk, even if it involves atypical science content. It definitely had its uses. In this case, I was able, at least superficially, to assess some of the students' understanding of the word "values" before I assigned them activities with values at the center. I could also satisfy myself that we had achieved a common comprehension of the word "values."

Immediately following the language clarification above, I informed the students that during this unit we were going to be talking about values. This information is delivered in a "teacher telling" mode.

> **Elaine:** These things we're going to be talking about -- it's easy in science to at least *pretend* that we're not talking about values? In this unit, we're gonna explicitly be talking about values. That doesn't mean that I'm gonna to tell you what to value, or that you're gonna have to argue for certain values; it does mean that things might, inside, you might feel a bit more emotional, maybe a little bit more tense than you're used to feeling? ... I just want us to remember that, remember it about ourselves, remember it about our fellow students, other people in the classroom. Ah, we always try, I know, to listen to each other and to respect each other's ideas; um, these next few days, you might just need to try just a little bit harder. Okay? Just, just be sensitive to each other; be sensitive to each others' beliefs and feelings, especially? Okay? I'm sure we'll be fine; we all know each other pretty well, so we should be fine.

I hoped that both of these moves -- defining values as a group, and then informing students of the centrality of values in the new unit -- would serve to lead sensibly into the new unit. I have included both of these here for two reasons: 1) to indicate how we got started on the unit, and 2) to demonstrate two kinds of teacher mediated talk that are useful, but not the same as the "genuine conversation" that emerges later on in the lesson.

Lesson Segment B: Intimations of Genuine Conversation

Following the work on defining values and contextualizing our upcoming treatment of them, I asked the students to return to a "survey" that I had given them the week before. The "survey" was actually a list of statements concerning applications of genetic engineering and medical technology, and the bioethical issues that these actual and possible applications imply. Examples of these statements are:

• Research into genetics should be regulated by federal legislation.

• A fetus should be aborted if by medical tests in the first trimester it is shown to be severely genetically defective.

• Society will one day mandate the use of scientific knowledge to produce individuals with certain inherited traits.

I had initially asked students to place a simple "yes" or "no" next to each statement to indicate their agreement or lack thereof. On this day, I asked students to place a number from 1 to 5 next to each statement. One indicated "absolutely positively always," 5 indicated "absolutely positively never," and 2, 3, and 4 varying degrees of "in between."

This exercise was meant to provide students with an introduction to some difficult ideas -- things, as I put it to them, that they would be deciding about as citizens in a democracy in the not-so-far-away future. Some of the language in these statements was unfamiliar to the students, and we spent a fair amount of time in question and answer mode, as they asked me the meaning of words like "debilitating" and "mandate." In this situation I chose to merely define these words for the students. Unlike the word "values," I suspected that they had little, if any, experience or knowledge of the words and phrases that they were asking me about. I have included excerpts of this portion of the dialogue to indicate the kinds of questions that the students had, and some examples of the comments that the statements were inspiring.

Tammy: Eighteen.
Elaine: "Research into genetics should be regulated by federal legislation."
Tammy: Now is that saying that, um, they have the power to say, like, that they can't do something, I mean --
Elaine: You, does this mean that federal legislation, meaning laws that would govern the whole country, um, would be able to say whether or not certain scientists or laboratories could research a particular thing.
Tammy: Oh!
Elaine: Okay?

Tammy: Umhm.
Misti: Number 1.
Elaine: "A fetus should be aborted if by medical tests in the first trimester" -- that's the first three months of pregnancy, right?
Misti: Yep.
Elaine: -- "It is shown to be severely genetically defective." And then they explain this by "the child would die before", "prior" means before, "before its 4th birthday."
Misti: And they'd do it on purpose, then, they would kill it.
Elaine: Yeah. If you consider abortion killing, then that's, what they're saying.

Misti : Okay.
Elaine: Kari?
Kari: (...) number 15.
Elaine: 15?
Alex or Sam: Yeah.
Elaine: "State and/or federal legislation proscribing who is genetically fit to reproduce should be enacted and enforced." That's saying that the state, or the federal government, could look at your genetic profile, and say yeah sure, go ahead and reproduce, or no you can't.
Tammy: That's like -- noooo -- that's like saying you can't, I mean, that's like saying you can't, you know, like Alex could go to the bathroom or something and Kari has to go real bad and she can't go, ya know what I mean? (Kari laughs.)
Elaine: (Laughs.) I think so.
Tammy: It was just a general (...).
Elaine: And I know, it sounds really totally bizarre to us, but it has, people have actually argued for this, um, certain societies actually tried to make it happen.
Tammy: Like for diseases and stuff, like if someone has a certain disease?
Elaine: It could start that way, but then it starts being certain things like --
Girl: Race?
Elaine:-- religion, race, ah, sexual preference.

During this time of term clarification, students were already engaging in declaring their opinions. The survey had turned out to be more inspirational in terms of expressions of beliefs and values than I had expected. I had not planned for this to happen, not at this point of the lesson. (I had planned for it to come in after the "Hammer Exercise.") So I pushed onward, even though students appeared ready to take up some politically and socially intriguing issues, including reproductive control, racial prejudice, and abortion.

In retrospect, these are exactly the issues that I had hoped would arise during this study. They are of the type that feminist critical pedagogy concerns itself with. These are issues I wanted students to encounter, connect to science and to politics, and use to develop a sense of personal power in terms of their own relationships with science. I erred in believing that they could keep these feelings bottled up until I said "go" -- until I decided, "Okay, *now* is the time to express our values."

The following dialogue is analyzed in detail, because it illustrates aspects of what I have described as "genuine conversation." It also indicates the struggles that I, as a teacher, engaged in as I attempted to chart a path for myself and for the students through the complexities of student talk. (See the end of the chapter for a complete transcript of the dialogue under study.) The three pieces of the dialogue analyzed are titled "Sharing My Uncertainty," "Controlling the Flow," and "Riding the Rapids." I hope that the reader will forgive this somewhat poetic imagery in the interest of helping me to explain the interactive and unpredictable nature of this classroom conversation. This language helps me to understand what was happening -- better than language that might be more traditionally logical and distanced from the situation.

Sharing My Uncertainty

One of my goals in teaching this unit was for students to realize that these issues are not cut and dried. Unresolvable complications arise within individuals as well as within the larger society. As the following dialogue begins, I have just asked students to address: "What might you say about yourself and/or other people if they had a lot of 1s, 5s, or 3s?" We have progressed to 3s:

Elaine: What about a person that had a lot of 3s? What do you think that kind of person -- (Students start talking again before I'm done; more than one person at a time).
Lily and others: Confused.
Jonathan: Complacent.
Elaine: I, I have a lot of 3s and I am *not* complacent. What I am is, um, uncertain about a lot of these things.
Misti?: It depends on the people, on the way that everyone else thinks?
Elaine: Excuse me (in attention-requiring voice). Becky?
Becky: A lot of 'em, I think it depends on like the cases, like. Ya know it depends on how bad, like that one thing talks about how bad that child's gonna be, ya know, whatever the word is.[21]
Elaine: Yeah, that, that seems to be my problem, when I look and one and say "Well yeah okay, what about this? What about that?"
Becky: I mean Down syndrome[22] it's gonna still survive, (...), I don't know. I don't even know if that's the case.
Elaine: Nina?
Nina: Well I think if you have 3s, it's that you have been shown both sides of the story, but it's still too hard to decide. It's like a value judgment, that maybe you're not ready to make because we (...).
Elaine: ...Do you mean we as like an individual, Nina, or we as a society, or ?
Nina: I think we as an individual. It's not that we only see one side.

[21]I think she means "defective."
[22]We had recently studied several "common" genetic disorders. Down's syndrome was one that many students had encountered in their lives -- real or television -- outside of school.

A distinction between individual values and individual cases arose very quickly in these students' talk.[23] Another strand of the conversation began with Nina's disagreement that certainty would come with more knowledge. Here, Nina is responding to a statement that Jonathan had made shortly before. I had asked what the students could say about themselves if they had all "1s and 5s." Becky said that they thought that that meant that "we're all about the same," and "that we think a lot alike." Jonathan, on the other hand, said, "Possibly they haven't been exposed to...different sides of the story." It appears that here Nina is connecting Jonathan's statement with my own; using her presumption of my knowledge and experience, she says that "it's that you have been shown both sides of the story, but it's still too hard to decide." This is one of the many places where students pick up on each other's comments. I consider students referencing each other's ideas and, especially, speaking directly to one another, to be a vital aspect of *genuine conversation* in the classroom.

Kari then picks up on Nina's comment, and continues her analysis of my own uncertainty in the face of the students' more common certainty in terms of the survey statements.

> **Elaine:** Kari?
> **Kari:** Well I was gonna say when they were sayin' that that um you have 3s? I think it is because you know a lot, so you know more about like both sides of everything, you know about everything, well you don't know everything, you know a lot, and so you --
> **Elaine:** Okay, I --
> **Kari:** -- you know there's different ways to doing different things.
> **Elaine:** Okay. I don't -- continue what you were saying.
> **Kari:** Well I'm just sayin' we have 1s and 5s and stuff, and I just think that, I just feel certain, cuz these aren't really, a lot of them aren't really of certain things? It's a lot of beliefs.
> **Elaine:** Um, I don't mean to imply that 3s is better than 1s and 5s, or that 1s and 5s are better than 3s (...).
> **Kari:** I think it's a lot of our beliefs and what you feel.

Interestingly, Kari moves here from a knowledge-based frame for choice that she and Nina have attributed to me to one that is based more in "beliefs and what you feel." Tammy

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[23]Later in the lesson, this distinction develops into an out-an-out argument between two groups of girls who hold different views on abortion. This will be pursued in detail in later work (Howes, 1997).

extends the conversation to include an additional aspect of knowledge, one that adds experientially gained belief to feeling.

> **Elaine:** Umhm. Tammy.
> **Tammy:** Okay. I've got a lot of like 1s down, for some of them, and um and they were like the ones where they say like the, they can control like whether or not you produce if you have, or like whether or not the baby should be born or aborted or whatever? And I put because um, and I have seen, and you know I could have put 3s for those but I have seen both sides of the story and I just think that it's not until you've seen both sides of the story (for 3s) and 1s and 5s are just the same. Because for like Down syndrome, like Becky said, I mean I know a child with Down syndrome and he's like, he's one of the smartest kids that I know (with emphasis). I mean like his age, and I mean I don't see what's wrong with him. There's nothing wrong with him but the way he looks. So I mean, it's not that you've seen both sides of it (...).
> **Elaine:** So, so maybe you're saying sometimes you have more information and more infor-, more experience and it might make you more certain rather than less certain.
> **Tammy:** Yeah. Yeah.

As well as claiming a certain kind of expertise due to experience, Tammy disagrees with Jonathan, Nina and Kari by saying that "it's not that you've seen both sides of it." She implies that seeing "both sides of it" will not necessarily make someone *less certain*. And, as Nina above, she refers to another student, Becky. This reference is used to support her own assertion.

Becky places the choice in particularity; in the "it depends on the cases" category -- she voices her uncertainty concerning knowledge of Down's syndrome, while recognizing that there is variation in degrees of disability. She implicitly denies the possibility of one generalizable rule for all choices, and yet does not support the idea that uncertainty indicates "complacency" or even "confusion." Nina more directly disagrees with Jonathan, supporting my statement that I have a lot of 3s and yet am not complacent, with "It's like a value judgment, that maybe you're not ready to make," even if I "have been shown both sides of the story." This, to me, implies the understanding that increased knowledge doesn't lead to surety, but maybe to even more uncertainty. These statements indicate a placement of choice in uncertainty, not complacency, and a valuing of the variability of cases (Purdy, 1996; Rothman, 1989; Wolf, 1996). Kari picks up on the idea of uncertainty, and carries it into the more typical arena of personal choice in terms of ethics: "I think it's a lot of our beliefs and what you feel."

On the other hand, Tammy responds (apparently mostly to Nina) to the conversation by insisting that she *has* had experience, and she *is* ready to decide. She picks up on Becky's Down's syndrome example, launching into a lengthy portrayal of her thought, experience, and potential decision making in this area. She may be defending herself against what she sees as a critique of certainty -- ironically! -- and asserting that experience can indeed lead to certainty. In her particular case, she is personally acquainted with a Down's syndrome child, and insists that his "case" has convinced her that his life is worth living: "He's one of the smartest kids that I know."

The girls here are demonstrating another aspect of *genuine conversation*, one that connects it directly to feminist critical pedagogy: They are combining experience, feelings, and beliefs to make their arguments and to describe their understanding of the world. It is tempting to say that these students are "making theory," as they travel among the complex connections set up by their own as well as each other's ideas and the abstractions of the survey statements. I am uncertain, however, whether this is actually the case. What does seem more evident is that students *are* using experiences and feelings to *describe* and *explain* their beliefs about these ethical issues. Occasionally, the conversation takes on a debate-like tone.

Kari sums up this portion of the conversation by placing choice squarely in the individual or couple. Jonathan is apparently impressed enough by the conversation thus far line of argument that he decides to publicly "re-examine" his statement.

> **Kari:** Cuz a lot of it has to do with like whether they have the right to do what they want.
> **Elaine:** "They" being whom?
> **Kari:** Parents.
> **Elaine:** Jonathan?
> **Jonathan:** Yeah, I think I'd like to re-examine my statement. I'm not sure that (...).
> **Elaine:** Okay great. Okay. (Laughter.) That's fine.
> **Alex:** Apology accepted.
> **Elaine:** I'm not sure that he --
> **Jonathan:** I wasn't apologizing (...).

This segment of dialogue demonstrates a very unusual occurrence: Jonathan, our resident science expert, changing his mind, apparently due to reactions that he was getting from his classmates, and me, to his statement that those people who were uncertain were "complacent" and his comment that people with 1s and 5s hadn't seen both sides of the issue. In this context of uncertainty and personal belief, Jonathan's usually unquestioned scientific pronouncements did not go unremarked. This kind of disagreement and discussion was something that I had hoped to make happen throughout my science teaching; here, it happens without my urging, but possibly aided by my honest example. Whether my "sharing" my disagreement with Jonathan, along with my own uncertainty concerning these ethical issues, "freed" these students to speak is almost moot. What is clear is that I did not "shut them up" with my statement.

By making myself into an "unknower" rather than a "knower" or a science expert, by making my own ambivalence plain, I may have nudged the authority of science off to the side enough so that the its silencing power was temporarily removed. I modeled the behavior that I wanted students to engage in throughout this unit -- that is, recognizing that uncertainty, contradiction, and "mind changing" did not indicate ignorance or lack of conviction, but intelligent thoughtfulness in the face of complex and troublesome ideas. The girls' adamant and energetic responses to Jonathan's and my statements illustrates one of the kinds of talk that I hoped students would practice. This is particularly notable to me because it was unusual: Jonathan was our recognized "science expert" and, to my recollection, was never challenged when he made statements of a more purely scientific nature. In this context, his female classmates refuse to let his statement go unnoticed; instead, they disagree and forcefully describe the logic of their disagreement.

This segment of classroom dialogue demonstrates that this talk is still teacher mediated, as I call on students and occasionally clarify and rephrase students' statements. However, I am not evaluating students' comments in terms of scientific accuracy. This would have been inappropriate, in any case, because the students were expressing experience-based knowledge that they understood better than any outside authority. I do not want to make my role in this discussion the most important one. I believe the *topic itself* allowed for powerful disagreement and the externalization of these students' personal stances.

Much of the discussion during this first lesson was unbidden by the teacher. During Lesson Segments B and C, I had intended that students would individually and *quietly* rate the survey statements. In responding to their questions about unfamiliar words and phrases, I meant to be merely supporting them in this planned task. I had not intended that this activity would be a context for discussing the ideas and controversial choices *themselves* that the statements were meant to introduce. I wanted students to wait until latter in the lesson to share their ideas. So, I moved on, even though they were saying very interesting things and engaging in the kind of discussion that I had hoped would happen during this unit.

Controlling the Flow

The second example indicates my control over the pace of the lesson and the direction that discussion is "allowed" to take. While again I utilized a piece of my life outside of school, it was more as a criticism of the students --- a mild scolding -- than it was genuine conversational fare. This made me feel artificial, and distant from the students. I was beginning to acknowledge, at least to myself, the tension between controlling the direction of students' work and wanting them to be free to express their ideas. It follows directly upon Jonathan's statement that he has altered his belief that people with 3s are "complacent."

> **Elaine:** Good example of changing your mind. (Some side talk.) Well, that would be an idea. But I have a different idea. And since I'm the boss we're gonna go with my idea. (The "idea" was to "go outside.) Hang on to your survey, of course. We're going to do another exercise, to help you think about, um, what you think about this kind of thing. (Kari asks a question.) Yeah, get out a fresh piece of paper please. And number it 1 through 23. (More side talk.)
> **Misti?:** I have an idea, Ms. Oren.
> **Elaine:** Uh-huh.
> **Misti:** Can we go outside? (Laughter.)

Sam: We need recess.
Elaine: Yeah. I agree.
Kari: (...) (Side talk.)
Elaine: Well, you guys, I planted trees yesterday at Emerson;[24] I didn't see any of you there.
Sam: That's when it was!
Becky: You said it was, like, yesterday.
Elaine: It was; it was also this past weekend.
Sam?: If you had reminded us, Friday --
Elaine: I know, I know, my fault. I'll take responsibility for that one. There will be other times. But if you get a chance, walk over there. Just go walk through there. It's really gettin' sorta neat. Emerson, the elementary school?
Becky: Yeah, they have a cool playground.
Elaine: Well it's gonna be even cooler now.

I have not found places where I can positively say that sharing an experience or belief of my own shut students up. However, here is a place where I certainly used my power to make things stick to my plan. I even diminished Becky's statement about the "coolness" of the Emerson playground. It would have fit my teaching philosophy and my gut respect for students as thinking, responsible, sensible beings if I had at least -- *at least* -- given them the floor, found out what they were thinking, maybe even gone with their plan about going outside, as far as the constraints and legalities of public schooling would allow. I also believe that my comments concerning Emerson could have been meant (or perceived) as a jab at the students for daring to challenge my plan. Although not overt, it allows me to maintain my "boss" status. Nonetheless, it is possible that my insistence on controlling the flow of this lesson opened up opportunities for students to continue discussion of this challenging topic. Despite my inner equivocation, I wanted this student talk to be under my control, or at least within my planned structure; I wanted them to talk about what I wanted them to talk about, when I wanted them to talk about it, and, of course, in my prissy New England brought up way, *one at a time*.

Distancing myself from the students here, I cut off the development of genuine conversation. Genuine conversation does not have a planned destination; science teaching typically does. I had not recognized that at this point in my learning about teaching. Now I

[24]This refers to a project at one of the elementary school in the district; I was involved in helping to plan and plant an "Outdoor Classroom." High school students were encouraged to help out for Honors Society "points."

am wondering: Does the very fact that we want students to learn particular content deny them the opportunity to engage verbally with each other, their teacher, and challenging ideas in science?

Lesson Segment C: The Executioner

Riding the Rapids: Sharing My Laboratory Experience of Killing Living Things

The upcoming activity, "The Hammer Exercise," was meant to get students thinking about their beliefs concerning the uses of living organisms in scientific research and connected technologies. The students would decide what it was okay for me to "kill," and what it was not okay for me to "kill." The list that I constructed for this activity is reproduced in Figure 8. It progresses from very simple life forms -- that is, if one even considers viruses "alive" -- to humans. This mimics a ladder form of evolution. I was uncomfortable with this hierarchy, because it is scientifically inaccurate, and because it implies that humans are at the "top" of evolutionary "progress." But the exercise was constructed with a focus different from evolutionary accuracy, one that would progress from life forms that students would probably find unattractive or inconsequential, gradually moving to life forms that they would consider beautiful, valuable, and even relationally important (e.g. cats and dogs, which many of them had as pets).

1. virus
2. bacterium
3. maggots (fly larvae)
4. mosquito
5. moth
6. dragonfly
7. crab grass
8. mouse
9. butterfly
10. daisy
11. pig
12. cow
13. crow
14. wolf
15. bluebird
16. kitten
17. cat
18. dog
19. chimpanzee
20. fertilized human egg cell (zygote)
21. human embryo (0 - 3 mos)
22. fetus (human fetus (3 - 9 mos)
23. adult human

Figure 8 - "The Hammer Exercise" List

The last sub-segment under study here was the piece that first got me intrigued with the larger segment of dialogue. I made what was for me an offhand, unplanned comment. As we were moving into the "Hammer Exercise," which required that I pretend to kill living organisms, I said, "What I'm gonna do (pause), and this is really hard for me to even say, because one of the reasons I left the laboratory, was I didn't like killing things?" As I was transcribing, I was powerfully struck by the students' insistence that I "tell them more." Rather than "controlling the flow," I begin to "ride the rapids" of this lesson, as students resisted my pressure to continue (at least with the alacrity I desired) with my plan. Instead, they insisted that I explain my offhand statement about "killing things."

> **Elaine:** Well it's gonna be even cooler now. Okay. One through 23; again, this is for your personal use? What I'm gonna do (pause), and this is really hard for me to even say, because one of the reasons I left the laboratory, was I didn't like killing things? But what -
> **Misti?:** You worked in a laboratory?
> **Elaine:** Yeah. But what I'm going to do is pretend to kill some living organisms. All right?
> **Tammy:** Wait.
> **Elaine:** Tammy?

Tammy: You like killed things for, like experiments?
Elaine: Uh-huh.
Tammy: What did you do, like you killed 'em?
Becky: What did you kill?
Elaine: Um frogs, and uncounted millions of bacteria. Nothing worse than that.
Tammy or Becky or Misti: Well, bacteria don't really count, do they?
?: No.
Becky: Aren't they like alive, though?
?: It's alive, but not really. (Lots of overlapping talk in here.)
Elaine: Okay, this is how this game works. (I'm talking over them; somebody shushes them.) Shhh, you guys. I'm going to name a living thing, and then I want you to write down the name of the living thing, and write whether or not it's okay for me to go ahead and kill it. I mean whether you say it's okay or not, I'm gonna do it(in a hard-guy mean determined voice). All right?

I had a continuum in mind myself, proceeding from what it's "okay" to kill to what it's not "okay" to kill, and for what reasons. I think that I may have indicated my scale to the students when they asked me what I killed and I responded, "Frogs, and uncounted millions of bacteria. Nothing worse than that." The comment, "Nothing worse than that," may have been a way of sharing my (unconscious) belief that there is a hierarchy of killing that puts bacteria at the bottom -- and anything else, possibly, is "worse" to kill. As I was embarking on an activity in which students themselves would encounter such a hierarchy in their own beliefs, I may have "contaminated" their reaction to the assignment by making this comment, spur-of-the-moment as it was. This is a feature of *genuine conversation*.

Why were the students so insistent that I expand on my comment? This is a place where I said something about myself: unplanned, it just made sense to say it. As in genuine conversation, it was honest. As in feminist critical pedagogy, it combined experience with feeling, and with science itself. Here I introduced the concept of myself as a "killer," albeit one who has sworn off killing. The drama of this idea may have been intriguing to the students. More pertinent, I believe, is the observation that this was not just some random fact about my biography, but one that fit in with the discussion at hand. In reality, in the laboratory, I *had* "killed living things." Here, as their teacher, I was going to *pretend* to "kill living things." So perhaps there was a connection between my laboratory live and this playacting activity. Or, maybe, I showed students that I myself was not comfortable with killing -- even when it was "just bacteria." Here, in terms of feminist critical pedagogy, I was sharing both an experience *and my feelings* about that experience. I was also implicitly critiquing, from a feminist perspective, the assumption that it is all right to kill living things "for the good of science." I was unintentionally modeling what I wanted the students to be able to do with the upcoming activity.

My "sharing" also allowed a digression into a more traditional student question/teacher response discourse concerning bacteria -- good ones and bad ones -- ironically inspired by what to me was an unrelated topic, that of bioethics. Students and I explored their understanding of living things, as they probed my knowledge in this area. I was, in turn, surprised and gratified that they recalled the questions of life that they had studied in the fall, some of them with me, in biology. This connection between traditional content and my work in the laboratory was not one that I had ever considered likely. What an odd time for my experience in the laboratory to come in handy!

Tammy: What kind of bacteria?
Elaine: That's a good question. Um, let's say, Tammy (talking over them) --
Jonathan: Bacteria (...) bacteria.
Girl S: Was it bacteria that is just taken away (...)
Kari or Elaine: Shhh, you guys!
Elaine: -- let's say, in this case, it doesn't make any difference, 'cause I'm just going to take a single bacterium. And you, you know, even the good ones, you, your bodies making those, I mean not your body, but they're in your body all the time; if I just take one out and kill it you'll still have plenty.
Tammy: But is it (...)?
Girl S or Tammy?: Can bacteria be good?
Elaine: Yeah. Yeah.
Misti: How? In what way?
Girl S: Kill it.
Elaine: Um, you have E. coli, in your digestive system that help you break down food. And for example if you get strep throat, and you take you an antibiotic, with means something that kills bacteria, you kill -- Misti I'm talking to you -- (little laughter) you kill a lot of those bacteria and you can get diarrhea. And then you go eat yogurt, which replaces those bacteria. So yeah, there are definitely good bacteria.
Girl S: Is it okay if I have a question mark there? Like maybe?
Elaine: No. You gotta say yes or no. Nope. No uncertainty.

At least three things are going on in the previous excerpt: talk about bacteria, deciding whether it's all right to kill a single bacterium, and clarifying the assignment. Understandably, students here are attempting to connect this "killing activity" with the previous "survey" activity in which there were shades of gray and uncertainty was allowed, even encouraged. Making this transition between games with different rules was probably not facilitated by my own switch from modeling uncertainty to being a strict, unfeeling executioner. Also, the idea that I, as a scientist, really did *kill* in my daily work as a laboratory scientist provided a "real life" example (albeit rather a tame one) of the bioethical issues that students were beginning to grapple. Is it any wonder that the idea of "killing innocent creatures" was the one that at least three students -- Tammy and Misti and Becky -- were able to make some relevant connection with?

Why did *this* "sharing of personal experience" engage the girls, while other efforts did not "work" to engage them in the activity or the science at hand? As I noted previously, I found the reaction from the girls to this off-hand comment quite puzzling. As do many new teachers, particularly if they have come from other scientific enterprises into science teaching, I consciously included my experiences in the laboratory at what I imagined were appropriate times. For example, during my teaching of genetic engineering techniques, I used my "hands on" experience, working with real DNA and real cells and real chromosome mapping questions to enliven the step-by-step, decontextualized protocol that I wanted the students to learn. In this effort, I was certainly sharing my experience and even my interests. But the soul and heart of my daily life in the laboratory were difficult to portray to high school students. And so I ended up leaving these out, instead portraying science as usual: a thing of mysterious, behind-closed-doors activity, doors labeled with radioactivity signs denying entry to regular people and personal values. Science remained special; I may have celebrated the push of curiosity, and thus appealed to students already intrigued by science. Nonetheless, even though my experience was cutting edge -- at the vanguard of molecular biology, the new darling of science, father of cloning -- it really wasn't, at its core, any different from any portrayal of science that students had ever seen. And it wouldn't bring me closer to them, but ensure my distance as an experienced foreigner in their school lives.

I always push my work in biological research as important, e.g. to prospective employers, yet here is the only place I recall students reacting at all to my comments. In contrast to teaching about recombinant DNA -- where I attempted to use my practical experience in this area to "bring it alive" -- these off-hand comments about disliking killing are the ones that not only naturally fit in, but intrigued the students. Much more so, for example, than trying to explain the workings of even basic molecular biology techniques to students. Although my experience was first hand, how could I expect them to tie into it when they had no vision of the minuscule amounts of volume, the carefully calibrated micrometer pipettes, the pumping of electrical current through gel to make little stripes seen only under UV light or through radioactive treatments? It makes sense that the vision of their teacher as a killer -- both in the reality of the laboratory, and fictitiously, through this exercise -- is much more enlightening and entertaining than that of their teacher as a technician.

"Disclosing" my self as an evil killing scientist as opposed to the uncritical celebration of science as "fun," I did something fundamentally different from indicating curiosity and experience as doors into scientific activity. This was a different kind of disclosure, as well, from that which I have encountered in the feminist literature: it wasn't about my sexuality; it wasn't about my personal relationships; it wasn't even directly about my feminist politics. It was mere honesty; not meant to persuade, not meant to indoctrinate; but simply to express my own feelings, and possibly, to put myself back into a community that loved life and deplored death. It was this love of *life*, after all, that had drawn me to biology in the first place. Thus, it may be, I connected with some of my students in a way that I never could by describing my laboratory experiences in conventional celebratory ways. I temporarily deserted the stance as all-knowing scientist, instead adopting that of a person puzzled by issues concerning the use of living organisms for the "good of science."

Normally I was so concerned that my students *appreciate* science that I shied away from criticizing its practitioners. Here I explicitly stated my own dissatisfaction with one of the practices of biological researchers: killing other living things to study the natural world. This is an example of participation in *genuine conversation*, as my statement brings a bit of my authentic self, specifically my disagreements with certain of scientists' research practices, into contact with my students.

During the portion of dialogue analyzed above, I didn't ask for any elaboration or justifications; I didn't say, "Would anyone like to tell us what reasons or criteria you used for rating the survey statements?" In fact, the plan was that students would just *write down* their criteria, privately. But they vocalized their ideas anyway, resulting in a lesson that was exactly the opposite of "it was like pulling teeth." In this dialogue, I myself talked about my beliefs and experiences in a way that deviated from a scientific statement of fact or practice. Initially, I expressed uncertainty; later, I gave as a reason for leaving laboratory work my discomfort with killing living things for scientific purposes. Is it possible that this "modeling" played some role in the students' willingness, and ability, to think and express their beliefs around bioethical issues?

Discussion: The Uneasiness of Genuine Conversation

I wanted students to feel that it was fine to express their feelings and beliefs about life, death, abortion, medical intervention, and human disability. As their science teacher, of course, I always wanted them to be comfortable letting me and their classmates know what they were thinking. However, I wanted to stress that the emotional issues we were going to encounter might make this particularly challenging. I especially wanted students to be careful not to denigrate their classmates' beliefs and values.

As a feminist critical teacher, I wanted students to talk, for two basic reasons: I believe that talking is vital to good learning, because one achieves deeper understanding by describing, explaining, making connections between one's life and scientific concepts; and because I want them to express their opinions, as a political choice. These two ideas overlap, particularly in the sense of connecting self to content. Throughout this unit, especially when students were saying exceptionally interesting things, with lots of people talking at once, I am reminded of Karen Gallas' (1995) hypothesis that when kids are making a conceptual breakthrough, they get very excited, which often results in lots of students talking at the same time. Unfortunately, this is usually considered "disruptive" behavior -- we continue, even in this enlightened time, to think that children should be seen and not heard. (Sometimes we even send them to in school suspension, so then they don't even need to be seen.)

In this context of bioethics teaching, a dilemma develops from the existence of two equally important demands that arise when my teaching plans forefront students' values and beliefs in science. The first is that the classroom environment be such that students feel welcome to express their thinking and feelings around sensitive, controversial issues of personal, social, and political importance. The second is that I, as a feminist critical eacher researcher, express my own values and beliefs concerning issues under study. My initial concern in this area was that students would consider my ideas the "correct ones," then fear to express their own if they differed from mine. I believe now that this is a lesser issue, at least in the context of bioethics, where students seemed to be holding to some form of "everyone is entitled to their own opinion." While students seemed to regard my "opinion" as more knowledgeable, possibly more sophisticated than their own, they didn't seem to view it as the final word (as they may have if it were going to be "on the test"). A different issue, therefore, has arisen for me. It still lies in the intersection of students' expression of belief and a "comfortable learning community." I am wondering now not only if this comfort is *possible*, but if it is *desirable*. Comfort may lead too easily to the cutting off of uncomfortable talk -- and uncomfortable talk is necessary for powerful learning.

Genuine conversation is uncomfortable, messy, and exciting. It contains personal experience, values, dreams, imagination, and factual knowledge -- to name a few -- all at once. It is fluid, as participants notice and react to others' ideas. It can be painfully emotional, especially in a classroom context where the teacher wants things to run smoothly, even if it means forcing dissension underground. For the teacher, it can seem chaotic, as she attempts to pull students' ideas together into some cohesive whole. In these aspects, the frustrations of students' expressions of experience, feelings, and beliefs appear something to be avoided rather than welcomed. But genuine conversation in the classroom can be very powerful, powerful enough that I want to learn to accept the inevitable uneasiness that it engenders. Learning to live with this uneasiness, and with the ambiguity in terms of students' learning that accompanies it, is required if genuine conversation is to become a part of one's teaching. It is also an opportunity to teach students that science, as life itself, is not cut and dried, even though it appears that way in textbooks, scientific publications, and its popular representations.

This study has made me profoundly wonder about my role as a feminist critical teacher in a science classroom. How could we make this kind of talk happen more often and effectively with traditional science content? Can we -- or does science itself deny the relativity and personal experiential knowledge that feminist critical pedagogy requires? On a more pragmatic line: How would this classroom have been different if we had begun the year with this kind of talk? Could we have carried genuine conversation into our studies of meiosis and deviation and protein synthesis? The feel of genuine conversation does not automatically translate well into classroom comfort, and yet I believe that this is what needs to happen, if progress toward respect for students and their thinking is going to be made.

In Table 8, I have summarized the aspects of *genuine conversation* as I have puzzled over them in this chapter. "Participants" refers to both students and their teacher. "Aspects" and "Requirements" may overlap.

These aspects and requirements are partly empirical and partly speculative. The most important insight that I have gained concerning genuine conversation is that it is unpredictable, and that the lack of predictability made me very uneasy as a teacher. I wondered, in real time as well as in retrospect: Where will this mode of talk take us? What does it have to do with students' learning in science? When should I stop it or guide it; when should I let go? I doubt that there will ever be final answers to these questions. That, in itself, is an aspect of genuine conversation.

Table 8 - Aspects of Genuine Conversation

Features of genuine conversation:

• It is fluid and unpredictable.

• Participants pick up on one another's comments: to disagree, agree, use as support, as evidence, and question the validity of their own or someone else's argument.

• It can feel chaotic, for teachers and students who are comfortable with more orderly classroom discussion.

• Participants combine experience, feelings, and beliefs to describe and develop their understanding of the world.

• The most powerful contributions to the conversation are "spur of the moment," inspired by the verbal action of the conversation in real time. This especially applies to the teacher, who may be used to pre-planned discussion questions, comments, and lecture.

• Participants offer experiences, feelings, beliefs, and knowledge that comes from all aspects of their lives, not just traditional school-based learning.

Requirements of genuine conversation:

• The teacher is minimally manipulative.

• The teacher becomes a learner about her students' beliefs, experiences, and feelings, as do the students about their teacher's beliefs, experiences, and feelings.

• A willingness from all participants to accept, or try to learn to accept, that uneasiness rather than comfort will very likely be a dominant feeling.

• An intriguing context for all participants.

• A insistence that all participants will be attended to and respected, even if (or especially if) other participants disagree.

• A tolerance for ambiguity and lack of closure.

Dialogue from Lesson Segment B

Elaine: What about a person that had a lot of 3s? What do you think that kind of person -- (Students start talking again before I'm done; more than one person at a time).
Lily and others: Confused.
Jonathan: Complacent.
Elaine: I, I have a lot of 3s and I am *not* complacent. What I am is, um, uncertain about a lot of these things.
Misti?: It depends on the people, on the way that everyone else thinks?
Elaine: Excuse me (in attention-requiring voice). Becky?
Becky: A lot of 'em, I think it depends on like the cases, like. Ya know it depends on how bad, like that one thing talks about how bad that child's gonna be, ya know, whatever the word is.
Elaine: Yeah, that, that seems to be my problem, when I look and one and say "Well yeah okay, what about this? What about that?"
Becky: I mean Down syndrome it's gonna still survive, (...), I don't know. I don't even know if that's the case.
Elaine: Nina?
Nina: Well I think if you have 3s, it's that you have been shown both sides of the story, but it's still too hard to decide. It's like a value judgment, that maybe you're not ready to make because we (...).
Elaine: ...Do you mean we as like an individual, Nina, or we as a society, or ?
Nina: I think we as an individual. It's not that we only see one side.
Elaine: Kari?
Kari: Well I was gonna say when they were sayin' that that um you have 3s? I think it is because you know a lot, so you know more about like both sides of everything, you know about everything, well you don't know everything, you know a lot, and so you –
Elaine: Okay, I –
Kari: -- you know there's different ways to doing different things.
Elaine: Okay. I don't -- continue what you were saying.
Kari: Well I'm just sayin' we have 1s and 5s and stuff, and I just think that, I just feel certain, cuz these aren't really, a lot of them aren't really of certain things? It's a lot of beliefs.
Elaine: Um, I don't mean to imply that 3s is better than 1s and 5s, or that 1s and 5s are better than 3s (...).
Kari: I think it's a lot of our beliefs and what you feel.
Elaine: Umhm. Tammy.
Tammy: Okay. I've got a lot of like 1s down, for some of them, and um and they were like the ones where they say like the, they can control like whether or not you produce if you have, or like whether or not the baby should be born or aborted or whatever? And I put because um, and I have seen, and you know I could have put 3s for those but I have seen both sides of the story and I just think that it's not until you've seen both sides of the story (for 3s) and 1s and 5s are just the same. Because for like Down syndrome, like Becky said, I mean I know a child with Down syndrome and he's like, he's one of the smartest kids that I know (with emphasis). I mean like his age, and I mean I don't see what's wrong with him. There's nothing wrong with him but the way he looks. So I mean, it's not that you've seen both sides of it (...).
Elaine: So, so maybe you're saying sometimes you have more information and more infor-, more experience and it might make you more certain rather than less certain.

Tammy: Yeah. Yeah.
Kari: Cuz a lot of it has to do with like whether they have the right to do what they want.
Elaine: "They" being whom?
Kari: Parents.
Elaine: Jonathan?
Jonathan: Yeah, I think I'd like to re-examine my statement. I'm not sure that (...).
Elaine: Okay great. Okay. (Laughter.) That's fine.
Alex: Apology accepted.
Elaine: I'm not sure that he --
Jonathan: I wasn't apologizing (...).
Elaine: Good example of changing your mind. (Some side talk.) Well, that would be an idea. But I have a different idea. And since I'm the boss we're gonna go with my idea. (The "idea" was to "go outside.") Hang on to your survey, of course. We're going to do another exercise, to help you think about, um, what you think about this kind of thing. (Kari asks a question.) Yeah, get out a fresh piece of paper please. And number it 1 through 23. (More side talk.)
Misti?: I have an idea, Ms. Oren.
Elaine: Uh-huh.
Misti: Can we go outside? (Laughter.)
Sam: We need recess.
Elaine: Yeah. I agree.
Kari: (...) (Side talk.)
Elaine: Well, you guys, I planted trees yesterday at Emerson; I didn't see any of you there.
Sam: That's when it was!
Becky: You said it was, like, yesterday.
Elaine: It was; it was also this past weekend.
Sam?: If you had reminded us, Friday --
Elaine: I know, I know, my fault. I'll take responsibility for that one. There will be other times. But if you get a chance, walk over there. Just go walk through there. It's really gettin' sorta neat. Emerson, the elementary school?
Becky: Yeah, they have a cool playground.
Elaine: Well it's gonna be even cooler now. Okay. One through 23; again, this is for your personal use? What I'm gonna do (pause), and this is really hard for me to even say, because one of the reasons I left the laboratory, was I didn't like killing things? But what -
Misti?: You worked in a laboratory?
Elaine: Yeah. But what I'm going to do is pretend to kill some living organisms. All right?
Tammy: Wait.
Elaine: Tammy?
Tammy: You like killed things for, like experiments?
Elaine: Uh-huh.
Tammy: What did you do, like you killed 'em?
Becky: What did you kill?
Elaine: Um frogs, and uncounted millions of bacteria. Nothing worse than that.
Tammy or Becky or Misti: Well, bacteria don't really count, do they?
?: No.
Becky: Aren't they like alive, though?
?: It's alive, but not really. (Lots of overlapping talk in here.)
Elaine: Okay, this is how this game works. (I'm talking over them; somebody shushes them.) Shhh, you guys. I'm going to name a living thing, and then I want you to write down the name of the living thing, and write whether or not it's okay

for me to go ahead and kill it. I mean whether you say it's okay or not, I'm gonna do it(in a hard-guy mean determined voice). All right?
(Some time passes, dialogue deleted, we go through killing virus, get to killing bacterium.)
Tammy: What kind of bacteria?
Elaine: That's a good question. Um, let's say, Tammy (talking over them) --
Jonathan: Bacteria (...) bacteria.
Girl S: Was it bacteria that is just taken away (...)?
Kari or Elaine: Shhh, you guys!
Elaine: -- let's say, in this case, it doesn't make any difference, 'cause I'm just going to take a single bacterium. And you, you know, even the good ones, you, your bodies making those, I mean not your body, but they're in your body all the time; if I just take one out and kill it you'll still have plenty.
Tammy: But is it (...)?
Girl S or Tammy?: Can bacteria be good?
Elaine: Yeah. Yeah.
Misti: How? In what way?
Girl S: Kill it.
Elaine: Um, you have E. coli, in your digestive system that help you break down food. And for example if you get strep throat, and you take you an antibiotic, with means something that kills bacteria, you kill -- Misti I'm talking to you -- (little laughter) you kill a lot of those bacteria and you can get diarrhea. And then you go eat yogurt, which replaces those bacteria. So yeah, there are definitely good bacteria.
Girl S: Is it okay if I have a question mark there? Like maybe?
Elaine: No. You gotta say yes or no. Nope. No uncertainty.

CHAPTER VII

LISTENING AS PEDAGOGY AND RESEARCH: WELCOMING UNCERTAINTY

Teaching and Listening

In this dissertation I have argued for "listening as research and as pedagogy." Listening, like many traditionally female traits, may be considered a passive and uninspired way of going about learning about the world. But real listening is a complicated, active process. This is especially true because as teachers, we are trained to speak, both from experiences in school and from our learning to plan and guide lessons and students' learning along predestined paths. We exhort our *students* to listen and learn. But we rarely develop learning contexts that support *our own* listening and learning about our students.

Keeping one's own silence in order to hear others takes energy. But energy for purposes in addition to self-control enters into this listening effort. Classroom contexts with students' words at their center are challenging to design -- and twice as challenging to implement. Neither students nor teachers in most present-day schools are accustomed to situations in which students speak more than the teacher (or the text), unless it is under constrained circumstances. Students are encouraged to speak in progressive classrooms -- through presentations, during group work, and in response to teacher questions. But when this talk begins to wander outside of content boundaries, it is guided back to the content, ignored, or cut off. I do not deny the desirability of focusing students' talk around the subject at hand. What I would like to do, more often, is to create contexts where students' talk is not controlled, but supported in wandering, crossing boundaries between content and daily life, between fact and feeling, and between rational and empathic modes of problem solving.

In order to move toward this complex goal, one of the many things that we need to attend to is what *students themselves* think about science as a social enterprise. My efforts to teach science in ways that allow students to recognize its socially embedded status have been intermittent and unsatisfyingly teacher-centered. Most successful and exciting have been those episodes in which I have tried to stay out of the way, supporting students in expressing their own beliefs, feelings, and understandings of science as a social enterprise. I hesitate to make any recommendations concerning what "teachers should" do in order to help students *alter* these beliefs, feelings, and understandings.

My temporary conclusion in terms of teaching students about science as a social enterprise, with all of the attendant political, social, and epistemological implications, is that listening to students is a necessary first and continuing step. I advocate this listening not in order to *change* students' beliefs about science, but to value their images and give them the opportunity to expand their visions.

Interview-conversations and Learning about Science as a Social Enterprise

Traditional academic science is abstractly cold and unemotional; it artificially leaves out the hearts and souls of the people and societies who create knowledge. Thus it attempts to approach the epitome of objective rational thought by explicitly denying the *subject* -- the person doing the research; the person learning about the world; the person explaining what s/he has learned about the world. In the context of bioethics, it becomes increasingly difficult and undesirable to maintain this separation.

The interview-conversations that I conducted with the students in this study were successful, and provocative, in getting kids thinking about science as a social enterprise. They explored scientific epistemology, questioning claims to objectivity and suggesting alternative ways that scientists might go about their work. How could one translate the context and the content of interview-conversations into classroom practice? In a regular classroom, one teacher is responsible for the learning of many students at once. This makes it very difficult to conduct conversations that temporarily leave traditional science content behind. To keep everyone's attention and value everyone's words was not difficult in one-on-one or small-group interview-conversations, where spontaneity and attention to each person's thinking was central. But this kind of talk threatens to disrupt typical classroom discourse, where the ratio of students to teacher is so much greater. The harmony of teaching and research was maintained during interview-conversations; I cannot say how this participation structure might be made effective in a whole-class discussion.

However, the questions that I posed during interview-conversations were bolstered by those to which I asked students to respond in writing during regular classroom time. In turn, students' written responses informed the questions that I asked during interview-conversations. In addition, my learning from my students during interview-conversations informed the questions and activities I designed for *all* of my students. Given more time, I believe that I would have taken my learning in this area further. Yet given the constraints of class size and the limited time we have with students to conduct interview-conversations as a regular part of our teaching, perhaps this would not be possible. But the specific questions -- or the scenarios that I chose for interview-conversations -- could be utilized in whole classroom situations. Students could conduct interview-conversations with each other; I wouldn't always have to be leading the group. Alternatively or in addition, students could report their learning, their comments, and their questions to their peers, stimulating a whole-class discussion around the issues that arose in small-group interview-conversations.

However, I would not want to give up the time that I had with students in one-on-one or small-group interview-conversations. As a teacher, I learned more from them concerning learning and teaching about science as a social enterprise than I believe I ever could have in the rush of classroom life. I also learned more about what it means to genuinely value students' thinking -- and in the end, grew to respect students' ideas about science more deeply and thoroughly. This learning may not translate directly into the design of classroom activities. It has, nonetheless, changed *me* so that I will redouble my efforts to construct situations in which students' ideas about science are central and play a larger role in my development of curriculum.

Connecting Girls and Science: Choosing Content Based in Women's Lives

Pregnancy, prenatal testing, and medical ethics fit well with calls for connection between science and students' lives, interests, and knowledge. These curricula allow in students' lives in authentic ways -- and students' lives contain politics, emotion, love, fear, bodies, sexuality, and other controversial and difficult concerns. In our individualistic society, issues of the body are considered private and personal -- at least, until we travel into issues concerning reproduction.[25]

I was aware of the delicacy of these and related issues during my teaching. Therefore my language appears to me, the feminist critical researcher, to be unduly indirect. On the other hand, as a feminist critical teacher, I recognize and value the teacher's efforts to leave room for *all* of her students' beliefs. I do not believe that the tension that arises when a teacher and her students' bring more complete selves into the classroom will go away with experience, be it individual or communal. On the contrary, feminist critical pedagogy presupposes and anticipates the common disharmony between traditional disciplinary content and students' beliefs and interests. Accompanied by a sensitivity to context and learners, and the aspiration for a better world for women, this unavoidable discordance provides feminist critical pedagogy with much of its *critical* power.

I was troubled that these young women were so powerfully demonstrating their passion for the protection of the helpless fetus, for a being that they see as human. They appear to be borderline judgmental of people who decide to abort when presented with evidence that the fetus is genetically "damaged." However, the traditionally feminine trait of caring is one that I want to celebrate in science. I believe that feminists do not make this point strongly enough, possibly because we fear the likely possibility that it will reinforce women's already constricted position as nurturers. Or maybe we just aren't heard when we avow: Caring is good. Caring *could* save the world. Standing up for the integrity of

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[25]See Michelle Fine (1988) for a searing account of how female sexuality has been banished from schooling.

each human life *could* save the world. Guns and bombs and standards won't -- that we know. We've tried guns and bombs and standards. Let's try caring, instead.

Science has traditionally excluded caring, and science teaching has followed in its wake. Therefore it is not surprising that the standards documents do not mention "caring" or "empathy" in their descriptions of scientific practice. Caring is not considered scientific, nor is it valued as an intellectual virtue. In pursuing democratic goals, however -- of which "science for all" is certainly one -- caring is a necessary "habit of mind." And as Deborah Meier states, it is one that we should actively *teach* in schools.

> Caring and compassion are not soft, mushy goals. They are part of the hard core of subjects we are responsible for teaching. Informed and skillful care is learned. Caring is as much cognitive as affective. The capacity to see the world as others might is central to unsentimental compassion and at the root of both intellectual skepticism and empathy....Such empathetic qualities are precisely the habits of mind that require deliberate cultivation -- that is, schooling. If such habits are central to democratic life, our schools must become places that cultivate, consciously and rigorously, these moral and intellectual fundamentals (Meier, 1995, p. 63).

No more than is listening, empathy is not passive. It requires knowledge, sensitivity, and understanding. And in feminist studies in revisioning science, empathy is beginning to take its place as an *intellectual* virtue -- as a way to learn about the world.

During our studies of prenatal testing, I was struck by the connections that girls were making between the content and their experiences outside of school. The classroom discussions and group-work talk that formed the basis of that chapter indicated their eagerness to share stories about pregnancy, childbirth, and children that were atypical of science classroom talk. While I was teaching this unit, I felt unable to help girls connect *directly* to the science at hand. But as a result of this research, of listening attentively to what girls were saying instead of focusing on what I wanted them to be saying, I learned that they possess a great deal of knowledge about pregnancy, childbirth, and children. The context of prenatal testing, as content, allowed them to bring this knowledge into the classroom. This, alone, is an adequate reason to choose content that connects to women's lives. And I am left with the question: How might our thinking about focusing on students' real life experiences look different if we make these experiences and this knowledge, rather than "the science," the center of the curriculum?

Genuine Conversation and the Unpredictability of Student Talk

There are many reasons that genuine conversation as I have defined it here is not common in high school science classrooms. Traditional and even most present-day science educators are primarily concerned with teaching descriptive, explanatory, predictive, and design-directed theories of modern science. For me, as a high school teacher, simply *making the time* for the study of something outside of an already full curriculum involved seriously wondering: Is this important enough to do even though we have so much to cover before the end of the year?

One thing I have learned from this research is that students always have plenty of important things to say. Students don't always talk about what they want them to talk about, nor do they always say what we want them to say -- either in terms of length or content. But when given intriguing opportunities and contexts with which to engage and a context that allows for rich and complex connections to their own experiences and passionate beliefs, these students explained to me and each other the feelings, experiences, and reasoning that grounded their beliefs concerning bioethical issues.

As teachers who work hard to make listening a part of their practice are well aware, we don't always hear what we want to hear. Students' comments about classroom work can be devastating, especially when they are negative and refer to something that the teacher spent a week designing to be intriguing for these particular students. Students' talk in the realm of content understanding can be confusing; in its midst and in its wake, we wonder what could be the best instructional path for each student's learning. In the context of genuine conversation, especially around controversial issues, the students are bound to say things that run up against the teacher's own deep beliefs and political convictions. Students' ideas and beliefs are not always safe for the teacher or conducive to curricular progress, or, in fact, supportive of classroom community building.

This reality isn't very comfortable! And it possibly provides another explanation for why this kind of talk doesn't happen as much as it might in high-school science classrooms. In science teaching, one can hide behind the exciting conceptual content; one can take the stance of objective knower; one can insist that exams and experiments and that next chapter are really what matters -- genuine conversation is too time-consuming and unpredictable to let happen regularly. The structure of the high-school day, week, and year leaves little time for the wandering and the confusion that can arise from attending to the undercurrents of students' lives and ideas.

Connections between genuine conversation rooted in students' ideas and the ideas in the standards documents are elusive. Assuming a democratic stance, mainstream educators, including those in science, recognize that new technologies spawned by science hit the social world and inspire debate as to its uses and controls. With this being the case, students need practice in applying scientific knowledge to informed, respectful debate: "Effective oral and written communication is so important in every facet of life that teachers of every subject and at every level should place a high priority on it for all students" (AAAS, 1990, p. 189). However, the mainstream goal is one that is set out as clearly subject-matter oriented, or, occasionally, as one that connects the uses of scientific knowledge in making personal and social decisions. In other words, the conversation is meant to produce accurate subject matter knowledge and/or provide practice in decision making that utilizes scientific knowledge in tightly prescribed ways.

The feminist critical goal is somewhat different. We seek to develop theory and action from shared experience and feelings. Nonetheless, coupled with an insistence that students be aware of the potential for current and future technologies to affect themselves, society, and the physical environment, contexts within which students can speak about challenging issues brought to us by science and technology are certainly ways for students to "apply ideas in novel situations" (AAAS, 1990, p. 187). Therefore, both the standards and feminist critical pedagogy value classroom conversation. But the goals are different.

The standards present conversation as a "tool" for learning. The same is certainly true of feminist critical educators. However, we take conversation as a good and an end in itself. The recommendation of Jane Kenway and Helen Modra that serves as the opening epigraph for Chapter IV bears repeating: "Perhaps we would do better to understand dialogue as the goal of pedagogy and not a condition for it."

Feminist scholarship gives us the theoretical, political, and moral backing for listening to students. Feminist research in education demonstrates the value -- the necessity -- of these efforts (Barbieri, 1995; Fine, 1988, 1993; Gilligan *et al.*, 1990; WISE Group at MSU, 1995). However, there is little, if any, in the feminist literature concerning critiques of science as a social enterprise that addresses or includes adolescents' ideas in this area. I think that we should start listening more attentively to hear what our "kids" have to contribute to scientific critique.

Welcoming Uncertainty

Listening more attentively has required from me that I learn to live with, and even value, uncertainty. When a teacher encourages students to say what they believe -- in interview-conversations, via students' writing, or during whole-classroom discussions -- discomfort is bound to arise. The contexts that I have studied in this dissertation allowed students to express ideas that were not always compatible with my own. These also required (at least from a feminist perspective) that I share my beliefs with my students. Teaching myself to expect the conflicts in belief that arose during these units was prerequisite to my being able to teach my students to do so.

Discomfort and uncertainty can be productive. How can we help teachers -- and students -- accept, value, and employ discomfort and uncertainty, typically the banes of a "well-functioning" classroom? This is where science teaching can explore possibilities for students' "social growth." This is where I think the full, genuine power of feminist pedagogy lies. Merely providing students with a context for talking is not a panacea for scientific illiteracy or a magic wand for teaching the politics of science. But at the very least, feminist pedagogy provides the teacher with a powerful context for making discomfort and uncertainty functional for both teaching and research.

Teacher research itself is an enterprise suffused with uncertainty. Teaching is difficult work, and one can rarely make amends for the pedagogical mistakes that reflecting on one's practice are bound to reveal. But one can learn so much from so little. In this study, I have focused on a few interview-conversations, two writing assignments, and two days of classroom discussion. Cognizant even of the lengthy chapters that have arisen from these foci, I still feel that I have so much more to learn, so much more to say.

So if I were forced to "give advice" to teachers embarking on studying their own practice, or, more pertinently, their own students, it would be to start small. Work with what you've got. Don't let the demands of scientific and/or university researchers get in the way of your listening to and learning from *your* students in *your* classroom via *your* plans and *your* decisions. At the same time, try to let go every once in a while. Set aside your plans and just listen to the kids.

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