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SCIENCE FOR ALL? AN INSIDER'S ACCOUNT OF CHANGING CLASSROOM DISCOURSE

By

Randy Kregg Yerrick

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Doctor of Philosophy

Department of Teacher Education

1994

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ABSTRACT

SCIENCE FOR ALL? AN INSIDER'S ACCOUNT OF CHANGING CLASSROOM DISCOURSE

By

Randy Kregg Yerrick

The purpose of this study was to examine how shifts in standard classroom discourse patterns would be understood by lower track science students. The researcher documented his daily efforts to renegotiate the classroom environment to that more representative of a scientific community. Data collection and analysis included student subject matter interviews, student journal entries, student models, and teacher/researcher reflections.

This paper is an analysis of the implicit and explicit obstacles inherent to shifting class discussions to classroom arguments examining tentative hypotheses. Discourse analysis of the arguments indicated that students interpret the treatment of knowledge and class rules through their own lenses of alienation and social conflict. The analysis brings into question the assumptions of current reforms and the absence of adequate theoretical frameworks to account for struggles he experienced when attempting to test the charge of "Science for all Americans."

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Dedication

This work is dedicated to the memory of my grandfather Kenneth Elgin Yerrick who passed away before it was completed. As a devoted school advocate and lover of children and how they learn, I know he would have liked to have read at least parts of this. His voice still echoes in my memory, "Did you learn anything, son?"

ACKNOWLEDGMENTS

My thanks to the many friends and family that continually reminded me that I could complete a task of this magnitude and that also reminded me that I volunteered for this task.

I want to express a special thank you to Suzanne (Suzanne M. Wilson) and Andy (Charles W. Anderson) for teaching me what it means to be a researcher. Your help was indispensable and my words insufficient to capture what your support has meant to me.

Finally, I would like to thank my lovely wife, Metra, who has remained with me throughout the ups and downs of graduate programs, parenthood, and other major transitions.

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TABLE OF CONTENTS

CHAPTER 1

OVERVIEW....2

REVISED SCIENCE EDUCATION IN THE LATE 50s....2

PRACTICAL CRITIQUE OF THIS REFORM....7

RETHINKING SCIENCE EDUCATION....10

CAPTURING THE AAAS 2061 VISION....13

Arguing Around Conflicting Views....14

Using Evidence as Authority....15

Treating Knowledge as Tentative....16

RECOMMENDATIONS FOR PRACTICE....18

MY RESEARCH QUESTIONS....24

DISSERTATION ORGANIZATION....26

CHAPTER 2

OVERVIEW....32

LEARNING TO TEACH....33

My Struggles Teaching Science in Public Schools....34

Looking Deeper into the Scientific Discipline....36

Portraying the Science as a Discourse Community....38

Portraying the Scientific Discipline as a Social Community....41

CLASSIFYING

CLASSIFYING

SELECTING A

Report

Resear

WRITTEN

INSTRUCTION

Popula

Instru

ANALYZING A

The So

Lower

Intern

How No

Effect

PREPARING T

INTERVIEW...

ENGAGING AL

PREPARING T

Interv

Instru

Fallible 43
Tentative 43
CLASSIFYING ARGUMENTS AS A SOCIO-LINGUISTIC PHENOMENON.....46
CLASSIFYING ARGUMENTS AS AN ACQUIRED DISCOURSE.....50
SELECTING APPROPRIATE PROBLEMS.....55
Reforms and Suggestions.....56
Researchers Suggestions.....57
MY QUESTION, "SCIENCE FOR ALL?".....58
INSTRUCTIONAL METHODS.....63
Population.....63
Instruction.....65
ANALYZING A LARGER SOCIAL PERSPECTIVE.....67
The Social Context.....68
Lower Track Science.....69
Internal Social Factors.....72
How Norms Propagate.....75
Effects of Homogeneity.....79
PREPARING TO OBSERVE THESE ISSUES IN CLASS.....82

CHAPTER 3

OVERVIEW.....86
ENGAGING ALIENATED STUDENTS.....86
PREPARING TO TEACH.....88
Interviews.....88
Instruction.....89

MY EFFORTS
Peer C
Side-T
Disagr
DISCUSSION.
TAKING A ST
Just A
Class
Planne
Extend
Teache
Arbitr
DISCUSSION.
ELIMINATION
DISCOURSE I
OVERVIEW...
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STUDENT AGE
Gainin
Less
THE PROBLEM
USING STRAT
Reneg
Acc
Produ
Gro

MY EFFORTS TO ESTABLISH SCIENTIFIC DISCOURSE FAILED.....91

Peer Criticism.....91

Side-Talk.....94

Disagreements about how to resolve arguments.....96

DISCUSSION.....102

TAKING A STEP BACK WHO ARE THESE STUDENTS?.....106

Just Another Monday?.....106

Class Conflict.....109

Planned Response Against Socialization Agents.....113

Extended Distance.....115

Teacher-Immersed Conflict.....120

Arbitrated Disagreement.....122

DISCUSSION.....125

ALIENATION AFFECTED MY STUDENTS.....127

DISCOURSE LEARNED IN THIS ENVIRONMENT.....130

CHAPTER 4

OVERVIEW.....134

PERSISTENT CLASSROOM NORMS AND DISCOURSE.....134

STUDENT AGENDAS THROUGHOUT THESE NORMS AND DISCOURSE.....137

Gaining Status Using Distractions and Social Attacks..138

Less Overt Distractions Related to Social Agendas.....142

THE PROBLEM MY NOT EXERTING AUTHORITY.....145

USING STATUS AND AUTHORITY TO SET NORMS.....149

Renegotiating Agendas of Social Status and "What" is Accomplished.....151

Products of Renegotiating Discourse Norms and the Group "Work".....160

Other Probl
Assur
Deter
DISCUSSION.
We Mad
Rules
INTERVIEW...
HOW FAR WE
INVESTIGATING
BELIEFS....
AN ARGUMENT
Recei
Remem
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Two si
New ro
Resol
MAKING SENS
Intera
Intera
WHOLE GROUP
ARGUMENTS A
INTERVIEWS
DISCUSSION.

Other Products Revealing a Renegotiation of Norms.....168
Assuring Everyone's Right to Disagree.....170
Determining the Correctness of An Idea.....172
DISCUSSION.....176
We Made Progress.....176
Rules Did Not Stifle Students.....179

CHAPTER 5

OVERVIEW.....184
HOW FAR WE HAD COME.....187
INSTIGATING ARGUMENTS FROM EXPERIENCES AND PERSONAL BELIEFS.....189
AN ARGUMENT UNFOLDING.....193
Receiving Recognition for Participation.....194
Remembering the Rules.....196
Hearing Evidence to Reach a Group Consensus.....199
Two simultaneuos but different arguments.....201
New roles for some.....205
Resolved?.....207
MAKING SENSE OF WHAT WAS SAID.....208
Interactions Were Partly Intellectual Struggles.....209
Interactions Were Also a Social Struggle.....210
WHOLE GROUP ARGUMENTS AND MY STUDENTS.....212
ARGUMENTS AS SOCIAL QUARRELS OR SOMETHING MORE.....215
INTERVIEWS REVEAL INDIVIDUAL CHANGES.....216
DISCUSSION.....233

OVERVIEW...

CHANGES IN

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Appendix A.

Toulmi

Appendix B.

Inter

CHAPTER 6

OVERVIEW.....239

CHANGES IN CLASSROOM DISCOURSE.....240

Students Changed.....240

Aspects of Discourse That Changed.....242

Aspects of Discourse That Changed Little.....244

ISSUES THAT STILL NEED BETTER UNDERSTANDING.....246

The Desirability of Scientific Discourse.....246

Teachers and Students Learning to Act, Speak, and Think Differently.....248

Analyzing and Understanding Changing Classrooms.....251

IMPLICATIONS FOR REFORMING SCHOOLS AND SCIENCE CLASSROOM...256

Balancing Issues and Reality.....256

Critical Barriers to Change.....259

Rethinking Effects of Tracking Students.....262

Struggles and Resistance.....262

Acquiring Instead of Learning Scientific Discourse....263

IMPLICATIONS FOR RESEARCH.....264

Studying What Happens to All Science Students.....264

Rethinking Central Issues of Science Education.....266

Finding New Ways to Discuss Scientific Literacy.....266

APPENDICES

Appendix A.....269

Toulmin's General Argument Framework.....269

Appendix B.....270

Interview Protocol.....270

Appendix C.
Pre P
Appendix D.
Addi
Appendix E.
Exampl
REFERENCES.

Appendix C.....273
Pre/Post Instruction Interviews.....273
Appendix D.....276
Additional Notes About Analyzing Classroom Discourse.276
Appendix E.....279
Example Timeline From Chapter 5.....279
REFERENCES.....280

OVERVIEW...
REVISED SCI
PRACTICAL
RETHINKING
CAPTURING
Argu
Using
Treat
RECOMMENDA
MY RESEARCH
DISSERTATI

CHAPTER 1

OVERVIEW.....2

REVISED SCIENCE EDUCATION IN THE LATE 50s.....2

PRACTICAL CRITIQUE OF THIS REFORM.....7

RETHINKING SCIENCE EDUCATION.....10

CAPTURING THE AAAS 2061 VISION.....13

Arguing Around Conflicting Views.....14

Using Evidence as Authority.....15

Treating Knowledge as Tentative.....16

RECOMMENDATIONS FOR PRACTICE.....18

MY RESEARCH QUESTIONS.....24

DISSERTATION ORGANIZATION.....26

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CHAPTER 1

Matching Practice with an Evolving Vision for Science Education

OVERVIEW

In chapter 1, I present the history of significant science education reforms that evolve in inquiry teaching in the past three decades. Then, I critique the philosophers' ideas and these reforms, and introduce new ways to think about science education. However, many ideas I use characterizing the new reforms are not recent ones; they are just now gaining acceptance by science educators interested in science education. In addition, I describe how these ideas capture the science as a discipline, and the problems with broad generalizations, general assumptions, and charges of what it takes to reform school science to benefit "all Americans." At the end, I organize themes to connect my findings with the recommendations of current reforms. As a result of this critique, I propose research questions that I answer in chapters 3, 4, and 5.

REVISED SCIENCE EDUCATION IN THE LATE 50s

The past 30 years has been hallmarked by two periods of science education reforms--those of the post-war Sputnik era and those that reflect the current thinking of reform like AAAS Project 2061. Though current reform thinking is built upon many common players and ideas of past reform, the resulting language and products contrast the old with the new.

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In the late 50's a major shift in thinking was on the horizon for science education. Many leading educators were describing the need for science education to be concerned about the structures of the discipline as opposed to the compilation of knowledge it produced. Bruner (1960) argued, "Grasping the structure of a subject is understanding it in a way that permits many other things to be related to it meaningfully. To learn the structure, in short, is to learn how things are related (p.7)"

Schwab echoed Bruner's emphasis on understanding the structures of the discipline and further argued that the processes that scientists go about "enquiry" would better represent science as a discipline in the classroom (Schwab, 1962). Science would be more useful and powerful for students if they were taught how to be better inquirers.

King and Brownell (1966) also argued that argued that accumulation of ideas was a less useful way to capture the discipline of science. Obviously ahead of their time, these philosophers argued that the scientific discipline could be more accurately characterized as a discourse among and between members of scientific communities. These philosophers depiction of science complimented Schwab's and Bruner's notion of science education in that students were a part of the discipline as well.

Each of these positions appeared to mark a departure from the notion of science as a list of facts and standard method by which scientists do their work. Summarizing the perception of science educators, Rutherford (1964) stated,

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> We are unalterably opposed to the rote memorization of the mere facts and minutiae of science. By contrast, we stand foursquare for the teaching of the scientific method, critical thinking, the scientific attitude, the problem-solving approach, the discovery method, and, of special interest here, the inquiry method (p.80)

Science education was blazing a trail to make science in the classroom look more like that of the activity that scientists carry out in their daily work. Leading science educator's recommendations were interpreted by their peers as a call for inquiry teaching methods. DeBoer (1991) described the new approach to be more inductive than deductive. He argued,

> Inductive approaches are based upon the premise that students can be inquirers in the classroom and generate meaning more or less independently by examining a variety of available learning materials. Under this approach the teacher acts as a facilitator rather than an authoritative dispenser of information (p. 210).

Science educators recognized the complexity of scientific thought and activity and sought ways to capture the processes of scientific inquiry. Classroom science had a new goal to capture the propensities of scientists as they made sense of the world.

According to DeBoer (1991) the interpretation of "inquiry teaching" struck divisions among science educators. On the one hand educators were helping students to go about inquiry without specific direction of accepted scientific ideas. Discovery teaching was an attempt to explicate processes that scientists use to find things out. These efforts virtually ignored the ideas that lacked specificity of content and generalized thought processes across the smaller subdivisions of science like biology, chemistry and physics. On the other side were science educators interpreting inquiry as directing students to

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independently construct currently accepted scientific concepts. This interpretation of inquiry came to be associated with the ideas of science.

The larger community of science educators portrayed a somewhat different understanding of science education than those promoted by Schwab, Bruner, and others. Their popular characterization of science in the classroom largely overlooked the work of these giants other than small gemstones in large works. Schwab's Invitation to Inquiry (BSCS, 1966) and Hawkin's contributions to ESS are testaments to this. The more popular characterization of science promoted in the 60's and 70's characterized the science curriculum as consisting of three parts: lists of scientific ideas, skills, and attitudes of children. Reform efforts like Science Curriculum Improvement Study (1970) and Harvard Project Physics were represented as lists of ideas for students to be taught and a set of process or skills that students needed to learn to perform. Popular thought promoted that the language needed to express the goals of science education would reflect these lists of ideas and skills for students to learn. Consider the title Science--A Process Approach (SAPA, 1967) or the example of Harvard Project Physics' goals.

> 1. To help students increase knowledge of physical world by concentrating on ideas that characterize physics as a science at its best, rather than concentrating on isolated bits of information.
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> 2. To increase the opportunity for each student to have immediately rewarding experiences in science even while gaining knowledge and skill that would be useful in the long run. (Harvard Project Physics, 1968)

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Since the implementation of such reform efforts, philosophers and educators have come to recognize the appropriateness of the work of Schwab and Bruner with respect to students' goals in science education. The widespread acceptance scientific process skills and concepts has come under increasing scrutiny. Popper argued against the notion of science producing fixed ideas (like list of concepts in textbooks) and proposed that science is more of a process of attempting to falsify competing positions (Popper, 1963). The list of ideas promoted in reforms were argued to be open for revision by future generations of scientists and philosophers like Kuhn argued that, regardless of the completeness of the list, the nature of science will ultimately end in revision of current ideas (Kuhn, 1962).

There was also criticism of the idea that scientific knowledge came directly from observations about the world. Popper (1963) argued that neither observation nor logical reasoning were the ultimate authorities over what ideas were important to scientists. All forms of evidence and methods of argument are relevant to evaluating an idea. Nuances of scientific work like the process of making inferences and influences of rationality were important aspects of scientists' knowledge and work omitted in the characterization of science as a list of ideas and skills to be learned.

Other critiques of the depiction of science originated out of considerations for planning effective curriculum in schools.

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Organization of scientific ideas and teaching scientific skills failed to account for elements of the students' experience with science and with school. Though Schwab (1962), Bruner (1960) and even Dewey (1916) had argued that learning should begin with the experience of the child, their advice was largely ignored. Schwab (1973) argued a necessary component of describing science in the classroom was knowledge of the milieu of the students and what important connections could be made between the subject matter and the student. Focusing on process skills and scientific ideas failed to account for how these ideas mapped onto the academic and personal components of students' lives.

PRACTICAL CRITIQUE OF THIS REFORM

While the science education community was still investing their efforts in inquiry teaching, studies were revealing that this type of teaching did not appreciably change the students' mastery of scientific concepts nor their ability to use scientific processes to solve problems (Thomas and Snider, 1969; Schefler, 1965). There was debate concerning the effectiveness of inquiry based teaching. These studies could have been influenced by the propensity of educational research to focus on process-product which clearly favor didactic methods but the skepticism gained momentum.

The largest impact this effort had on changing the nature of science instruction was found in the influx of reform materials used in classrooms. DeBoer argued that the actual practice, however, looked quite different from the intended vision (DeBoer, 1991). While the recommendation promoted

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teachers telling students about the scientific ideas and organizing class around opportunities for students to gather evidence to support scientific ideas, the actual classroom instruction ranged from didactic to content-driven to discovery teaching. Studies revealed inquiry teaching to be very much absent from the average classroom (Anderson and Roth, 1985, Welch, 1981). Welch argued,

> For many years, the science education community has advocated the development of inquiry skills as an essential, outcome of science instruction and for an equal number of years science educators have met with frustration and disappointment...although teachers make positive statements about the value of inquiry, they often felt more responsibility for teaching the facts, 'things which show up on tests', 'basics', and structure and work ethic. (Welch, et al, 1981, pp.33-37)

Welch went on to report that teachers felt inquiry teaching caused too much confusion and too difficult for any but the brightest student. Teachers often resorted to science instruction that required students to remember lists of scientific ideas and use them in expert ways. These methods tended to favor the academically inclined and thus science was geared for the brighter students in school.

Despite the commitment of the larger body of science educators to drive home important concepts, studies revealed that students were not attaining the goals that reforms had laid out. In the general field of science education children across the nation were not learning science very effectively. (IEA, 1988, Mullis and Jenkins, 1988). One interpretation of this reform's effectiveness attributes the failure to the inadequate

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representation by the majority of science educators of science as a set of ideas, processes, and attitudes. It failed to account for several aspects of science and classroom instruction like the effect or prior knowledge students. Some researchers argued that presenting the ideas to students ignores the sense that they have already made of the world and that students preconceptions of physical phenomena were "amazingly tenacious." (Ausubel, 1968; Smith and Anderson, 1986). Though Bruner (1960) and Dewey (1916) had both argued long before that learning should begin with the experience and understandings of the student, reform efforts largely ignored how the children's preconceptions of the world affected their learning of science.

Another interpretation of the failure of this reform to change science instruction is that it failed to account for difficulties specific to he nature of teaching. Sarason (1982) argues that reforms like the post-war science effort fail as a result of focusing on outcomes and not the specific details of implementation. One specific difficulties of teaching is the dependency of the teacher on the success of the students. Cohen argues that classroom instruction is highly resilient to change because of this relationship and that conservative teaching strategies prevail for reasons other than "their demonstratable superiority." (Cohen, 1988).

Still another interpretation of the failure is the omission of other school agendas like socialization. Researchers argued that the school setting itself encouraged the practice of fragmenting the content and disconnecting it from the lives of

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children or the body of knowledge it represented. (Goodlad, 1984; and McNeil, 1986) This practice of teaching to lists of ideas and mastering certain processes for credit led to a deskilling of the students and a representation of science that was disparate and foreign to the students' lives as well as unrecognizable from the connected body of knowledge it had been derived (McNeil, 1986; and Apple, 1979).

Though this tendency to fragment and misrepresent the discipline was prevalent in most classes, it was especially predominant in classes of disadvantaged learners. Reports of lower track science classes revealed that students were be offered access to different types of knowledge that would limit their options after graduation (Oakes, 1985; and Anyon, 1981). Science had become a way to limit access o certain types of knowledge to certain groups. This was recognized by several as a cultural bias that advantaged certain majority groups and not simply an issue of students not learning subject matter (Delpit, 1988; and Anyon, 1981).

RETHINKING SCIENCE EDUCATION

The failure of this reform to have a profound impact on the practice of teaching science led to a rethinking of science curriculum that has gained momentum in the past decade. Standing on the shoulders of giants before them researchers, philosophers, scientists, and educators presumed that changing science education would involve more than explicating inquiry skills, important concepts, and student attitudes. Much of this current rethinking echoes recommendations of former

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educational leaders such as Bruner (1960), Hawkins (1969), Rutherford (1964), and Schwab (1962), who were voices that had been central to the changing conversations of the post-war era but whose ideas had largely gone unheard.

The evolving effort to redefine science education began with a new definition for science educators of what science is. Reformers attempt to capture the proclaimed values of science and use them in the intended curriculum by redefining science education: "science is in many respects the systematic application of some highly regarded human values--integrity, diligence, fairness, curiosity openness to new ideas, skepticism, and imagination. Scientists did not invent any of these values , and they are not the only people who hold them" (AAAS, 1989, p. 134); and

> Science is open-ended, but scientists operate with expectations based on predication of theory. Scientists use a pre-existing body of observations, facts, inferences, hypotheses, and theories to build their expectations of what will happen and to guide further inquiry. Scientific knowledge must be presented as authoritative, not authoritarian...we can always learn from new discoveries. Science is based on observations set in a testable framework of ideas...Science is not a matter of belief; rather it is a matter of conclusive evidence that can be subjected to the test of observations and themes. (California Framework, 1991, p. 1)

The description of science itself has changed in the rhetoric of science education. Reformers have attempted to capture in the intended curriculum the proclaimed values of science. Their attempts to redefine and carve out new notions of science are recognizable through their us of the phrase "science is..." Science is now thought of a way in which a group of people think, act, and speak with one another. The

lists of ideas and processes have been replaced with the notion of a more collective activity in which groups of individuals struggle together work in communities sharing common language, goals, and modes of inquiry.

Moreover, science education reforms have rejected the notion that only certain students should learn the values that scientists operate by. The values and ideas new science education reforms promote are perceived as fixing certain social ills and extend to "all Americans."

> To reach all students means reforming the education of every strand of the student body--vocational, general, and college preparatory. For students who expect to go right on to work after high school, a narrow focus on trade skills will no longer do; they need to acquire a strong base of scientific knowledge and of reasoning, communication, and learning skills. All college bound student, quite apart from what they believe their majors will eventually turn out to be, need to enter college with an understanding of science...The recommendations in this report, therefore, apply equally to all students. (AAAS, p.1989, 157)

Unfortunately, reforms are conspicuously silent when concerning the methods or specific details of how these values will become the norm in classrooms. The community of scientists and educators see different limitations to implementing scientific discourse. While scientists think there is no problem combining scientific thinking and acting in classrooms, they do perceive a problem with content being watered down. Therefore, their focus is simply on the "ideas" and the integrity of their use.

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scientific work force. Also, they have to follow a curriculum, and other procedural aspects of classrooms that require teachers to treat students as something other than a group of mature independent adults. These restrictions keep teachers from responding with open arms to turn students loose to study freely on their own as scientist might.

CAPTURING THE AAAS 2061 VISION

One way to understand the values and work of scientists operating in communities is through analyzing the discourse they share (King and Brownell, 1966 ; and Lemke 1990). Discourse refers to a large set of issues rather than simply ways of speaking. Discourse is

> a socially accepted association among ways of using language, of thinking, and of acting that can be used to identify oneself as a member of a socially meaningful group or "social network"...Think of discourse as an "identity kit" which comes complete with the appropriate costume and instructions on how to act and talk so as to take a particular role that others will recognize. (Gee, 1987, p.1)

Through this lens of discourse, the scientific community is taken as the unit for analysis, not simply its concepts or process skills. Educators can use discourse to focus on the ways these scientists interact so that students can assimilate the same actions and values of scientists. There are many ways to interpret the vision of Project AAAS 2061. One way is a representation of the elements found in a scientific discourse community. A few of these elements include:

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2) using evidence as authority
3) treating knowledge as tentative

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Each key element is a valuable component for scientists' work propagated through scientists' interactions as members of a scientific community.

Arguing Around Conflicting Views

> In various forms, the mass media, teachers, and peers inundate students with assertions and arguments, some of them in the realm of science, mathematics and technology. Education should prepare people to read or listen to such assertions critically deciding what evidence to pay attention to and what to dismiss, and distinguishing careful arguments from shoddy ones. Furthermore, people should be able to apply those same critical skills to their own observations, arguments, and conclusions, thereby becoming less bound by their own prejudices and rationalization. (AAAS, 1989, p. 138)

This component of reform 2061 requests that educators prepare students to form arguments as a part of making scientific sense of the world because arguing and attempting to falsify claims are core scientific activities that determine how to redefine and retain ideas (Popper, 1984 and Kuhn, 1962). Researchers attempt to capture the nature of scientific arguing as something other than an individual act (Lemke, 1990); it is a socio-linguistic activity in which previously agreed upon rules of engagement drive and direct all involved members. Members recognize when other members employ the important elements of arguing--hypotheses, warrants, and tentative claims--, and respond accordingly in predictable ways (Lemke, 1990 and Toulmin, 1958) by gathering relevant evidence through experimenting, making inferences about existing evidence that refute or support the claim, and offering counter hypotheses that contradict the initial one.

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When members step outside the accepted rules of engagement, the scientific community and other influential affiliations--funding agencies--quickly take action to correct the improprieties (Lemke, 1990 and AAAS, 1989). Therefore, if scientific communities are to be the classroom-norm, educators, themselves, must figure out how to communicate and sustain these values as ideals since reforms do not specifically explain how to integrate these values as classroom-norms.

Using Evidence as Authority

> Sooner or later scientific arguments must conform to the principles of logical reasoning--that is, to testing the validity of arguments by applying certain criteria of inference, demonstration, and common sense. Scientists may often disagree about the value of a particular piece of evidence, or about the appropriate of particular assumptions that are made--and therefore disagree about what conclusions are justified. But they tend to agree about the principles of logical reasoning: What connects evidence and assumptions with conclusion. (AAAS, 1989, p. 127)

This component of reform 2061 portrays arguments as being resolved by using evidence and rational thought. However, within the scientific community the true test of an idea is whether the scientists can explain all known evidence better than their competitors. When promoting competing ideas, scientists present evidence to convince opposing factions that one side is superior. This promotional arguing technique allows competing notions to shape science as a community and the knowledge produced (Kuhn, 1962).

This view of authority illustrates that members within the scientific community do not use their social status as leverage to resolve arguments. While scientists do maintain affiliations

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that grant power and status within their groups, status results from mastering argumentation and does not resolve controversy. As a result,

> History is usually written by the winners, but science that survives does so because ideas and findings have withstood constant further inquiry. In science, it is not the struggle of individuals that matters, but of ideas and evidence against competing ideas and evidence. Controversies in science should be presented as matters of evidence, not of personalities. (AAAS, 1989, p. 205)

Even though this ideal is worth pursuing, researchers outside the policy circles argue that, in reality, scientists' daily work does not look like the pristine image this reform portrays (Lemke, 1990 and Traweek, 1988) because status and other interpersonal conflicts play into their daily work. However, scientists still maintain that members using the hypotheses and inference discourse are equally influential in scientific debate and remain productive while traversing such obstacles involved in human interaction.

Like scientific communities, classrooms are not immune to status influences. Reseachers argued that arguments resulting from collaborative student work usually do not uphold such ideals and these students are not productive in the same ways as scientists (Eichinger, Anderson, Palicsar, and David, 1991). As a result, reforms and research still have to specify how students and teachers can maintain a rational argumentation ideal in the midst of the sloppiness of human interaction.

Treating Knowledge as Tentative

> Students should experience science as a process for extending understanding, not as an unalterable truth. This means that teachers must take care not to convey the

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> impression that they themselves or the textbooks are absolute authorities whose conclusions are always correct...science teachers can help students to balance the necessity for accepting a great deal of science on faith against the importance of keeping an open mind. (AAAS, 1989, p. 150)

As presented in this component of reform 2061, the tentative nature of knowledge leaves ideas open for criticism and revision with new and better ideas. This reform reflects revisionists' notions of study disciplines portraying a continuing process that reinvents ideas and rediscovers new ways to view the same events (Kuhn, 1962 and Mink, 1987). Scientists value competition among ideas, subsequently inviting alternative explanations into their argument arenas. Regardless of their development, all ideas are tentative. Therefore, if students are going to learn to act scientifically, they need to learn that science does not end in one conclusive experiment that proves one side.

> Most scientific work does not result in infallible propositions, such as the word proof seems to imply to the nonscientists...But science never commits itself irrevocably to any fact or theory, no matter how firmly it appears to be established in the light of what is known. Science is never dogmatic; it is pragmatic-always subject to adjustment in the light of new observations...This is a cardinal property of science. It is not a weakness of uncertainty by a strength of self-correctability. Students should be carefully taught this intrinsic value. (California Framework, 1991, p. 15)

Each key discourse component is an important aspect of scientists' work. The scientific community shares a discourse that incorporates specific ways of speaking, thinking, and acting that are recognized and valued by its members. These communicating techniques are what make members a part of the same community and limits communicating with other communities

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(Gee, 1987; Schwab, 1962; and Mink, 1987). Classrooms are a different community, serving different purposes, carrying different charges for its members and make communication scientifically limited and difficult. As a result, these new roles and responsibilities seem reasonable and desirable, but the acquired capabilities stretch current understanding of science education and raise new issues and questions arise. How will elements such as tentative language and argumentation fit into the context of regular classrooms? What are potential barriers or obstacles to equipping one community's discourse with the norms of another?

RECOMMENDATIONS FOR PRACTICE

This new vision for science education as presented in reform 2061 means a new form of instruction that encourages science teachers to instruct children to act in the same way scientists act and to value what scientists value. Teachers need to treat science differently by asking students to interact with the teacher, subject matter, and peers in different ways. Students need to ask more questions, construct arguments, and analyze problems as a cooperative group led by the teacher. Therefore, teachers need to transform their classrooms into communities where they facilitate open-ended inquiry and guide students through the practices of this new scientific discourse.

> ...teachers should encourage students to raise questions about the material being studied, help them learn to form their questions clearly enough to begin to search for answers, suggest to them productive ways for finding out answers, and reward those who raise and then pursue unusual but relevant questions. In the science classroom, wondering should be as highly valued as knowing...In

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> science classrooms it should be the normal practice for teachers to raise such questions as: How do we know? What is the evidence? What is the argument that interprets the evidence? Are there alternative explanations or other ways of solving the problems that could be better? (AAAS, 1989, p. 149)
>
> Students should be given problems--at levels appropriate to their maturity--that require them to decide what evidence is relevant and to offer their own interpretations of what the evidence means This puts a premium, just as science does, on careful observation a thoughtful analysis. Students need guidance, encouragement, and practice in collecting, sorting, and analyzing evidence, and in building arguments based on it. (AAAS, 1989, p. 148)

Ideally, students interact like scientists and act according to what scientists value as a group. Tentative questioning replaces memorizing facts. Using available evidence as an authority to resolve arguments using answers in the back of teachers' textbooks as authority. Teachers and students have new roles and responsibilities to groups as their speaking, thinking, and acting shift collectively.

However, treating scientific knowledge as tentative is not the norm for school science inquiry. A host of influences shapes classroom instruction making knowledge more final-form and driving science instruction to be more conservative. Teachers and students function in environments dominated by standardized tests, textbooks, and, in some cases, social control (McNeil, 1986) promoting a singular type of discourse recognized in most science classrooms. Lemke (1990) and Cazden (1988) found teachers and students participate together to promote a discourse structure that places teachers in the final authoritative position over placing values over comments throughout classroom discussion.

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What do educators need to change the community discourse of a classroom? If teachers practice the key scientific discourse components in regular classrooms, they, single handedly, need to work against the tide to change the groups' expectations and discourses. Together, these people have to unlearn the schools' ways while operating within it. Unfortunately, there is little direction to help teachers decide how to accomplish this task.

Therefore, to make these changes, teachers have to understand some of the differences between school and scientific communities. What kind of knowledge do members of each community need in order to successfully participate in discussions? How do members acquire or modify knowledge as a group? Changing classroom discourse involves more than simply deleting some talk and inserting new ways of speaking, requires altering how students think about their whole school experience as well as how they think about themselves, because children learn more than how to think about subject matter; students learn the implied "hidden curriculum," which constitutes knowledge and ways they are "supposed" to interact with it in the school environment.

> Appropriate participation in key classroom events such as lessons requires a considerable stock of social and academic knowledge. Students need to learn not only the academic content of their lessons, but situationally appropriate ways of interpreting and responding to their teachers' talk about the content. By their interpretation and responses, students learn about content and demonstrate their learning to teacher and peers. (Florio-Ruane, 1987, p.189)

Unfortunately, some students learn ways that conflict with some of the recommendations of current reforms. According to

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students' situations, they learn specific ways to interact with scientific content that misrepresent scientific communities.

Therefore, unfortunately, not all students learn the same implicit messages about what constitutes scientific knowledge and how they "should" use it. For example, lower track students or students of lower socio-economic status, are often taught knowledge in final form. As a result, teachers give them fragmented pieces of factual information that they are to memorize (Oakes, 1985 and Anyon, 1981). By closely examining this hidden curriculum, teachers realize understanding science is different among different groups of students.

This revelation indicates lower track students have more difficulty mastering new discourses dependent on constructing a new kind of knowledge than higher track students in more affluent schools. Yet, AAAS overtly encourages making this change on all classroom levels. So, teachers must consider what happens in these classrooms where they promote new discourses that only some students will predictably acquire. Gee (1987), and Michaels and O'Connor (1990) argued that by promoting scientific discourses and confronting nonscientific discourses risk devaluing students' prior knowledge and discourse practices. Promoting a singular discourse such as that used in science classes runs the risk of contradicting or even devaluing a community's accepted ways of speaking, thinking, and acting. Gee views discourses as

> ...inherently "ideological." They crucially involve a set of values and viewpoints in terms of which one must speak and act, at least while being in the discourse; otherwise one doesn't count as being in it...Any discourse concerns

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> itself with certain objects and puts forward certain concepts, viewpoints and values at the expense of others. In doing so it will marginalize viewpoints and values central to other discourses. (1987, p. 4)

Accomplishing a total discourse transformation requires teachers to make connections between students' knowledge and discourse practices with the desired changes toward a more scientific discourse. They cannot simply enter classrooms and announce, "We're going to talk and act differently today." If teachers did, students would have trouble learning what was appropriate and would most likely interpret such a change as devaluing their current discourse patterns. As a result, educators are not clear how classroom discourses or even discourses specific to a certain ethnic background revere while being replaced with another type of discourse. Attempting to make this replacement requires a delicate balance and a considerable amount of knowledge about students' backgrounds and science. However, it is still not clear how to accomplish this within school environments.

In school environments, where tracking and homogeneous grouping prevails, devaluing students' discourse patterns means further separation for students who are already on the boundary of the school culture. In fact, Michaels and O'Connor (1990) supported this belief by arguing that trying to teach a discourse in environments representing today's classrooms simply expands the gap between those students who already practice this discourse and those who do not.

> In the absence of more objective criteria for what counts as a good text, or a good answer, teachers often work with discourse expectations that are personal implicit,

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> privileging those students who share the same set of interpretive strategies and discourse assumptions as the teacher. If you don't come to school already controlling the elements of the discourse, it never gets unpackaged for you. (p. 24)

Because discourses are complex networks of social interactions and are inherently ideological, researchers argue that school is a difficult place to appropriate different discourses to students (Gee, 1987; and Michaels and O'Connor, 1990). If attempts to teach science to "all students" is to avoid further alienation of some students from science, then educators need to explicitly work out the differences in discourses and strategies used to help students acquire new discourses. Ignoring these differences exacerbates the separation between learners who have already acquired such discourse practices from those who have not (Ogbu, 1988; Steele, 1992; Gee, 1987; Michaels and O'Connor, 1990; and Heath, 1989) Researchers recommend that educators find ways to involve students' culture in making connections to the expected discourse about subject matter and not to marginalize students' present discourse practices (Au, 1981; Heath, 1989; and Delpit, 1988).

There is little variance from researchers or reformers for the recommendations to change existing traditional settings to make them more sensitive to cultural differences and minimize practices that promote control over student thinking. However, there is little documentation to explain what teachers should expect when challenging traditional science classroom norms. There is even less known about what major issues arise as a

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result of attempting to change the norms of students already alienated from science. The charge of "science for all Americans" speaks directly to those students already labeled as disadvantaged from learning science in nontraditional ways and these students have their own set of issues and concerns related to the way they interpret school.

MY RESEARCH QUESTIONS

Science educators are in the early stage of making attempts to articulate a solution. Researchers, reformers, philosophers, scientists, and educators are coming closer to agreeing on a vision for science education that engages students in ways that are similar to the work of scientists like previous recommendations; however, they lack details teachers need to accomplish their classroom goals. Classes, described in their recommended vision, are not prevalent in good to average settings and are even less prevalent in lower track classroom settings. Therefore, if their aims are to be useful for "all Americans," then the test of this vision lies in the most challenging environments--lower track classrooms.

For this reason, I wish to study introducing these scientific discourse components into a real classroom setting. Introducing scientific discourse into other venues such as alternative education programs or other institutions outside school fall short of testing the charge of "science for all Americans" since educators write these reforms with this vision in mind for today's public schools. Schools are a logical place to study the problems associated with introducing new norms into

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a setting rich with messages of how teachers and students "should" interact with science. Further, I wish to test science educators' reform vision with highly alienated students--students who do not practice scientific discourse well and are in lower-track classes because of their ways of speaking, thinking, and acting in schools. As a result, I intend to test the challenges of "science for all Americans" in a classroom where reformers say scientific discourse components must work.

This brings me to the questions I have about teaching science using components in these ways: 1) What does a classroom that embodies some of the reform recommendations described above look like? and 2) What has to be done to create an environment where this kind of discourse is possible?

My story analyzes the changes in classroom environments, issues, and conflicts that arose as I attempted to enact my understanding of the visions called for by AAAS Project 2061 and similar efforts. In formulating questioning and planning this class, I draw from my experiences as a teacher and as a research chemist, my knowledge of current research related to schools, conventions of separate cultures, and establishments of new forms of speaking, thinking, and acting in school and outside communities.

As a result, I inform, educate, and perhaps complicate the conversations between two camps of educators: those who speak about teaching and learning in the rhetoric of reform and those who devote their efforts to understanding classrooms and their common agendas more closely related to schools and their

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communities. Though this story will not reveal all that my students or I experienced, struggled with, succumbed to, and rose above, it does map out some of the main territory a teacher can expect to traverse in instituting such visions of science teaching and learning.

DISSERTATION ORGANIZATION

The remainder of my dissertation is a chronological story of events that reflects what it is like trying to embark upon change. I explain how I got there, when I found my preparation was insufficient to understand my struggles, and how I used my authority as teacher to shape the "work" and products of the classroom community through a series of re negotiations. In the process, I apply the scientific discourse components presented in Project 2061 and address my questions, which ultimately contribute to my understanding of what I found while researching my own teaching.

Chapter 2 introduces how I came to understand teaching and choose such a perspective to examine my students. I describe what experiences as a teacher, a scientist, and a graduate student framed my questions and shaped the answer to the question I had long sought after, "What does it mean for a group of students to act scientifically?" By framing my literature review and selection of my research methods chronologically, I present my evolving understanding of the problem I studied. For additional methodological information and clarification, refer to Appendices.

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Towards the end of chapter 1, I describe my need to consider other research perspectives to understand my research question, as I confront stark contrasts between the ways my students and I interpreted school and our task at hand. I help define more clearly what my interpretation of research and reform calls for and highlight the conflicts between these recommendations and the lives of my students.

Although I was clearly aiming for the changes in discourse, which I finally discuss in chapter 5, chapters 3 and 4 precede these changes in order to describe the obstacles I dealt with while trying to establish an environment that makes scientific discourse even possible. These two chapters mainly deal with issues relevant to my students' understanding of school and their place in it. In each chapter, I convey issues that keep us from establishing meaningful class discourse.

In chapter 3, I start to answer my research questions related to different forms of discourse. Major themes that pervade are situational specific classroom *discourse*, *alienation*, and *resistance*. This process begins with pre-interviews with my students to understand how each one goes about constructing arguments. Next, there is an analysis describing how the social milieu of the peer group in which these students attempted to construct arguments complicated these differences in discourse practices. I identify how students' common understandings of general education classrooms keep me from promoting the discourse I seek. I address the issues of side-talk, struggles of social status, and different

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ways students think of argumentation. Newmann (1992) and McNeil's (1986) notions of alienation are themes of my students' responses. I also use the theme of placing necessary boundaries on discussions and modes of operations that I feel were necessary.

Chapter 4 answers my research question about establishing an environment where I sustain a new discourse form. Themes that dominate this chapter arere negotiating the "work" of the community, struggles for social status, and the role of teacher authority in renegotiating both. I describe my attempt to empower the my students' voices by protecting them from the barbs of their peers as well as carving out opportunities for them to speak directly to one another about subject matter in authentic ways. I explain the need of teachers as facilitators and drive from students an established set of rules and punitive reactions for students directly involved in the blocking, diversion, or resistance to new norms. In addition, I explain that the school organization and policies, and the treatment of knowledge is intricately woven through elements of discourse used by teachers to keep students in line. When teachers lift the control over knowledge in some way, students' may interpret that their teacher will never exert control over them. The key issue defines teacher control as two separate functions--that of promoting discourse by decreasing control over ideas, and increasing control over socialization processes to promote community progress.

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Chapter 5 gets to the heart of changing discourse practices that occur sometime later in the first semester. I continue to answer the questions about establishing avenues for new forms of discourse, while beginning to answer what scientific discourse may look like in a setting of challenged learners. Chapter themes include using arguments for proof as well as elevation for students' *status*, and connecting them in classrooms. I examine the students' tendency to insert struggles to gain status into the intellectual struggles of the class. Apparently, students have acquired certain discourse patterns, both individually (post-interviews) and collectively (analysis of classroom discourse), but I conclude that differences between social and intellectual struggles of scientific argumentation are often indistinguishable.

Chapter 6 presents what I learned. I reflect on the changes my students underwent, highlight the changes that coincided with reform recommendations and, if left to stand alone, would point to success of my attempts to change their discourse, and point to other undesirable aspects of my students discourse. Though my students did, in many ways, practice scientific argumentation, there were personal, collective, intellectual, and social costs associated with such gains. Still, I wonder to what degree total transformation of a classroom culture to a scientific one is possible or even desirable. I conclude discussing the implications for school and further research.

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CHAPTER 2

OVERVIEW.....32

LEARNING TO TEACH.....33

My Struggles Teaching Science in Public Schools.....34

Looking Deeper into the Scientific Discipline.....36

Portraying the Science as a Discourse Community.....38

Portraying the Scientific Discipline as a Social .....

Community.....41

Fallible 43

Tentative 43

CLASSIFYING ARGUMENTS AS A SOCIO-LINGUISTIC PHENOMENON.....46

CLASSIFYING ARGUMENTS AS AN ACQUIRED DISCOURSE.....50

SELECTING APPROPRIATE PROBLEMS.....55

Reforms and Suggestions.....56

Researchers Suggestions.....57

MY QUESTION, "SCIENCE FOR ALL?".....58

INSTRUCTIONAL METHODS.....63

Population.....63

Instruction.....65

ANALYZING A LARGER SOCIAL PERSPECTIVE.....67

The Social Context.....68

Lower Track Science.....69

Internal Social Factors.....72

How Norms Propagate.....75

B66

PREPARIN

Effects of Homogeneity.....79
PREPARING TO OBSERVE THESE ISSUES IN CLASS.....82

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CHAPTER 2

How I Got Here

OVERVIEW

This chapter serves two purposes: one, to introduce experiences that prepared me to teach; and two, to present teaching experiences I used to direct relevant literature, primary and secondary research, and reform documents to fit what educators understood about science education. As a result, I explain how social norms in groups are changed and acquired. Considering the nature of my research question, I traversed and cited a wide range of educational literature ranging in scope from understanding the scientific discipline as different discourse communities, to the resiliency of the teaching practice, to the school's role in social class conflicts. Therefore, this substantiates my teaching and learning beliefs that are rooted throughout this teaching experience.

As a result of my previous educational and teaching experience, and my research, I address several points in Chapter 2. First, I explain teaching science can be interpreted as teaching a scientific discourse and my limited success as a public high school science teacher drove me to look deeper into the scientific discipline. As a result, I explain how literature portrays the scientific discipline as a discourse community and a social community, which is fallible and tentative. Therefore students have to acquire a secondary discourse where they argue appropriate unestablished scientific problems, without a final authority. To select these problems,

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I referred to reforms and researchers. As a result, my studying influenced my choice of pedagogy.

It is through this lens of scientific discourse that this dissertation views science teaching and learning. I describe instructional and analytical methods I chose, and the problems I ran into that thrust my research into a new arena--that of schools alienate and disengage students through tracking. Therefore, I analyze the larger social perspective of lower track students by studying the social context, lower track science, and internal social factors, how these elements spread within a community, and the effects of homogeneity that are underscored by the charges of "science for all Americans." In conclusion, I mark the territory my research can add to the current understanding of teaching a new vision for science in public schools.

LEARNING TO TEACH

In 1986, after learning I did not really enjoy my job as a research chemist because this career was not rewarding, I entered the teaching field. During my undergraduate years and my brief chemist experience, I held many teaching related jobs where I conjured up images of helping students enjoy science as much as I did. As a result of these experiences, I had an advantage over most teachers (or so I thought) because I knew what scientists "did." I believed my subject matter knowledge and experiences could provide motivation and models for students' ways of thinking that would stretch beyond the average classroom definition of learning science.

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Even though my formal training came from Michigan State University's (MSU) Academic Learning Program, it is difficult to pinpoint where I learned how to teach. At MSU, I learned how to assess students' preconceptions of subject matter knowledge, how to design lessons that directly confronted misconceptions that ran counter to thinking scientifically, and how to interview and engage students in the processes of explaining real world problems in order find out how they think.

My Struggles Teaching Science in Public Schools

My first teaching job was at an affluent school where everyone said I was lucky to obtain a position my first year teaching because the school was a "good school" that boasted 90% college placement. The parents of this "good school" were involved in their children's' education and pressured my students to earn good grades. I also received pressure, from my department chair, to cover certain content by the end of the year because students "needed" to know specific ideas in order to succeed in the departmental exams or the Advanced Placement courses. Therefore, my students also thought content was important; so important, that they were compulsive about finding out exactly what was required to pass my class. This, however, was not my objective.

As a result of my education at MSU, I taught in ways that elicited students' prior knowledge about the world and devised ways to directly change their misconceptions that researchers warned could impede students' learning (Ausubel 1968; Posner and Strike, 1990). So, I portrayed science content as groups of

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ideas and skills to please my department chair and applied my teaching style to learn if my students really understood these ideas. Unfortunately, however, while I raced through the curriculum to remain on the curriculum schedule and tried different ways to convince students of superficial ideas, I knew they did not understand, nor did they approach problems the same way scientists did.

As a result, this teaching approach placed me behind schedule and at odds with my department. Unfortunately, our disagreements about content coverage never got to the heart of our differences. The department wanted quantity and I wanted quality where students learned how to do different things. Soon into the school year, in order to pacify my supervisor, I fell into teaching patterns that bothered me.

After overhearing my students tutoring one another, I became dissatisfied with what my students were learning. They adopted the mottoes: "Just do this," and "This is what you *need* to know;" they were not good at stating *why* things happened. At this point, I realized I taught them that it was not their job to think about *why*, but instead to tell me something happened because scientists said so.

I was unsure how to stop perpetuating my students' false use of scientific truth that science was organized according to chapters consisting of fragmented groups of facts with correct answers. Sometimes, I demonstrated how to explore concepts by leading them through experiences and experiments. However, when they got stuck and asked for help, they pressured me into

telling them the correct answer and, out of frustration, I told them explicitly what to know for the exam.

We fell into the familiar discourse patters researchers such as Cazden and Lemke had described, explored, and explained. Cazden had discussed the I-R-E pattern as predominating classroom discourse. Teachers **I**nitiate a question to which they know the answer; students lobby for turns to **R**espond; and teachers give an **E**valuative response to students' answers (1988). Lemke (1990) had also described a similar pattern--Triadic Dialogue--to which I later came to understand how classes operated, but I was unsure why this discourse pattern was insufficient for meeting my objectives--to learn science the way scientists did through using evidence.

As a result of settling into this I-R-E pattern, I became the subject matter authority who judged students' experiments results as correct or wrong. After completing their labs students asked, "Is this correct?" This type of discourse pattern was far different from the means and methods I, as a chemist, used to judge results. My students wrongly assumed there was a correct answer that I should tell them. There must be an alternative way to teach the scientific discourse.

Looking Deeper into the Scientific Discipline

I was a hypocrite; I knew science was something other than what my students were learning in my class, but I didn't know where to look to help me understand my struggles. Schwab (1962) wrote of such struggles to be true to one's discipline,

> ...We will need to face the fact that methods are rarely neutral. On the contrary, the means we use color and modify the ends we actually achieve through them. How we teach will determine what our students learn. In a structure of teaching and learning is alien to the structure we propose to teach, the outcome will inevitably be a corruption of that content. And we will know that it is. (p.229)

My teaching efforts were inadequate in getting students to act like scientists, and the fact I knew this was worse than blissfully going about teaching the way it had always been done.

After reading some of Lortie's research (1975), I realized he would have argued I taught in ways I learned from my "apprenticeship of observation." In addition, my struggles could have resulted from ignorance. However, ignorance was not the only factor because I was aware of the different ways of teaching and applied them on several occasions. But, unfortunately, because students were comfortable and successful, and I was comfortable and familiar, I always fell back into the conservative teaching role.

In addition, Cohen (1988) would have explained that because my struggles were adventurous and heavily influenced by my students, the nature of my work was the problem. When I ventured into foreign territory with teaching new approaches, I depended upon my students' cooperation and influence; however they were not supportive or even neutral. The reason being, their parents pressured them to succeed in school and success was measured by grades and other conservative measures, not by trying. Defeated, frustrated, and pessimistic, I bargained out a path of least resistance.

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Yet, other scholars (McNeil, 1986; Goodlad, 1984; and Cusick, 1983) would have suggested my bargaining precipitated from schools' numerous conflicting charges--educating students about subject matter, socializing students with appropriate behaviors and attitudes, and providing students with credentials so they could move on with their lives. Therefore, I was forced to teach students information they needed to pass the semester exam and move onto college. In the process of reaching toward this end, my students and I collided with difficult ideas or struggled through a new teaching method. Researchers (McNeil, 1986; Goodlad, 1984; and Cusick, 1983) would have described these as common routes of classroom bargaining teachers pursue to re-establish the understood norms of classroom participation.

While struggling to organize my class differently and to help students learn the chemistry I knew, I received little help from my colleagues and school personnel. As a result, in order to explore and better understand my struggles, I took an educational leave of absence.

Portraying the Science as a Discourse Community

Returning to MSU, I learned more about the science discipline and why portraying scientific ideas in the classroom was difficult. Contrary to my thoughts, I discovered nobody knew what the science discipline resembled (Schwab, 1975). One feasible portrayal involved a community enterprise working together toward a common goal. This interconnectedness was the solution to my teaching problem; I could approximate scientists'

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work by examining how they worked with one another. To accomplish this objective, I researched primary sources.

I researched scholars' work portraying science as a community that jointly pushed forward the discipline's knowledge. Several scholars had suggested science evolved around several collective activities involving discussing, refining, verifying, and refuting claims (Kuhn, 1962 and Mayr, 1982). Engaging students in arguments was an enticing way to get them involved in science and to act like scientists; my helping students to better understand how scientists made decisions would best convey the culmination of scientists' work.

However, I needed to know specific details how scientists argued and established ideas through discussing ideas, explaining results, and justifying answers. With this insight, I could teach students how to argue and use evidence, and they would be less apt to ask, "Is this correct?" Contrary to my belief, Popper (1963) had argued scientific ideas were established in the discipline through falsifying community's claims. However, my students viewed science as a process of proving an answer to be *correct*. But Popper had argued there was no ultimate "truth" and, hence, only successive approximations were made by eliminating false ideas. This skepticism of ideas and group discussions of ideas was important, but I did not know how to engage students in challenging scientific ideas or what this process would be like in a classroom. Besides, my students could not feasibly act as

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a community in attempting to falsify the ideas textbooks promoted.

Fortunately, Toulmin (1958) provided me with another way to think about scientific arguments. He had outlined recurring and distinguishing aspects of argumentation that included warrants (W), data (D), backing (B), claims (C), rebuttals (R), and qualifiers (Q). He had argued warrants were used to validate or refute data interpretations that provided backing for the warrants, and if these warrants were effectively argued, then a claim was made and refuted, and perhaps supplemented with a qualifier as to when warrants applied to this particular event (See Appendix A).

Toulmin had presented a detailed description of how scientists argued. As a result, I understood where the common language of science such as hypotheses, theories, and data fitted into this argument framework, but he had also given me reason to discard the five-step scientific method as the scientists' argument process. This five-step method was prominent in all the textbooks and was what I taught and struggled against each year. Unlike this method, warrants had a richer meaning because they included questions that had arisen, predictions that evolved, and conjectures that were refuted. In addition, Toulmin's model had not promoted a linear or cyclical development of experimentation. Instead, his model had accommodated for instances of Kuhn's "normal" science that concluded in proving the status quo as well as scientific activity operated outside the accepted paradigm (Kuhn, 1962).

Because data informs or influences warrants, Toulmin's model was better than the textbook model that presumed a hypothesis generated in a vacuum.

Engaging my students in arguments that appealed to evidence better represented what I understood about the scientific discipline. I was not surprised to learn current science education reforms were informed by the same influences as I and called for similar practices.

> Students should be given problems--at levels appropriate to their maturity--that require them to decide what evidence is relevant and to offer their own interpretations of what the evidence means This puts a premium, just as science does, on careful observation an thoughtful analysis. Students need guidance, encouragement, and practice in collecting, sorting, and analyzing evidence, and in building arguments based on it. (AAAS, 1989, p. 148)

Still, to make this happen in my classroom, I needed to identify other important characteristics of scientific communities. I had to discover how groups work together to construct knowledge; how arguing skills are acquired by individuals within groups; and what types of problems are appropriate for my students to argue. Even though I discovered a fruitful idea, I was still a long way from understanding how to get my students to argue like scientists.

Portraying the Scientific Discipline as a Social Community

These frameworks did help me comprehend how ideas are challenged, but did not help me understand how communities argued collectively. Describing what scientists did to reach a conclusion could not be captured by simply tracing the development of widely accepted ideas. The nature of social

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interactions they shared was important as well. I knew there was a dynamic interaction between ideas and individuals, for my mentors and I often relied upon one another for insights into our problems.

This social psychological explanation argued individuals gained definition to their ideas by "positioning" themselves in social interactions with others and ideas did not originate or become refined in the abstract. Friere (1970) would have further argued that not only were ideas changed by interactions, but contexts were also changed. Individuals, ideas, and situations interacted and do not exist separately from one another. As Friere wrote,

> Men, as beings "in a situation," find themselves rooted in temporal-spatial conditions which mark them and which they also mark. They will tend to reflect on their own "situationality" to the extent that they are challenged by it to act upon it. Men *are* because they *are in* a situation. And they *will be more* the more they not only critically reflect upon their existence but critically act upon it. (p.100)

Another description of the social nature of scientific ideas was embodied in the structures of the discipline. Schwab (1975) explained *what* was talked about (substantive structures) were influenced by *how* these ideas were argued or investigated (syntactic structures). King and Brownell (1966) also pointed to the structures of the scientific discipline as key factors in identifying *what* and *how* things were decided. Therefore, scientific community members influenced one another through criticism and acceptance of ideas; their intellectual work was encroached upon by their need to receive social acceptance.

This dependence on other members to define and critique ideas runs the risk of examining only solutions imagined from a predetermined mind set, making scientific social communities fallible.

Fallible

In short, scientists discover what they look for, right or wrong. Kuhn (1962) described scientific community errors spread by pursuing popularly accepted ideas. He argued that "normal" science was a pursuit to re-establish current beliefs, despite conflicting evidence. As a result, science was filled with errors, controversies, and dead-ends.

Fleck (1979) also explained, through recounting the concept of syphilis, science was fallible, was influenced by historical context, and was driven by the community members' understandings and interactions. These examples clarify that science was not simply an abstract, intellectual process, but, rather, was deeply tied to members collectively pushing and pulling at ideas, leaving products tentative.

Tentative

These accounts of scientific wrong turns gave me additional reason to believe that scientific knowledge was tentative because I began understanding science was the ebb and flow of human thought, and scientific arguments were not pristine summaries of ideas. Instead, real arguments occurred within a social context only when the community agreed the idea in question was still open for discussion. In my classroom, I had not captured the ability to hold an idea open for questioning

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for any extended period of time. If my students were to argue, they had to believe there was a valid reason.

Philosophers of other disciplines questioned the idea that deductive arguments were complete representations of what was important to know about the discipline. Kline (1970) believed creating deductive arguments was only a final shaping-up knowledge, and not very useful either. In fact, he argued deductive arguing was one of the least effective ways to engage students because deduction results when an idea was completed, dead. Responding to such criticism, mathematical standards (NCTM) fought to include more engaging forms--forms reformers now say are important for students to acquire--of mathematical discourse or register because mathematicians collectively invent conjectures and pursue support for ideas.

In step with other disciplines, science reformers now call upon teachers to treat scientific knowledge as tentative, not personal battle, but a push and pull of ideas. AAAS promotes a more rational development of ideas and consistency in the nature of the work of scientists to establish ideas.

> Instructional materials should encourage responsible, science-based discussion of controversial or contentious issues. Science should be portrayed as a vital, changing endeavor with controversy and competing lines of intellectual discussion--not sterile, dogmatic discipline in which facts are known and approaches are agreed on. Historical growth of science should be reflected in controversy. This desideratum must be explained carefully. History is usually written by the winners, but science that survives does so because ideas and findings have withstood constant further inquiry. (AAAS, 1989, p. 205)

Teaching science using this prescription separated the ideas from the social context and the individuals who spawned them.

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This prescription was skewed, perhaps unintentionally, from some accounts of science from insiders' perspectives. Many accounts of science (Traweek, 1988 and Latour and Woolgar, 1986) do not appear so rational, organized, systematic, open, and free of social influence as popularly marketed.

Lemke (1990), a former nuclear physicist turned socio-linguist, promoted a slightly different perspective of how theories were accepted within the scientific discipline.

> How does as scientific theory become established?... Historically, a new theory always begins as somebody's way of talking about a topic or problem. They argue for their theory, or someone else does, and convince others. A faction appear that lobbies for the theory in many ways: by research papers, by experimental tests of predictions, by talks at scientific meetings, by writing books and textbooks, and teaching students, and so on. In the end, a community of people, and most influential, the most powerful people within that community, determine which of the theories get published most, used most, taught most. (p. 125)

Lemke focused on the daily grind of the oral and spontaneous nature of science, including the members' treatment of ideas. He argued science was not strictly composed of arguments in final, clean versions reforms encourage. Instead, influential individuals, groups, and even paradigms shaped the social construction of ideas.

This message was not meant to criticize the AAAS's portrayal of what science should be because scientists hold this vision for themselves and find ways around their members' social tensions in order to maintain a productive community. Therefore, their products reflected rational, evidence-based theories that explained the world better than their opponents. As a result, somehow, through all the messiness of human

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interaction, scientists do find ways around their differences and bias, and continue their progress.

However, science, is fallible and, therefore, tentative. Unfortunately, retelling the development of the current atomic model did not teach my students that scientific knowledge is tentative. Instead, they accepted the current scientific explanation without questions, but their acceptance had to do with the treatment of knowledge in school. Before elaborating how I thought about getting my students to treat knowledge differently, I must first describe how arguments, a central tool in scientific thought, are socially influenced and shared by the community's members.

CLASSIFYING ARGUMENTS AS A SOCIO-LINGUISTIC PHENOMENON

The logical organization of scientific ideas seemed insufficient; understanding science as a social/intellectual process was more reasonable because how else could I account for dead-ends or wrong conclusions in science? Logical arguments represented only part of the work in science, perhaps the most artificial part. To teachers, activities promoting "finding out..." seemed more important than activities hinged on "concluding that...." Intuition, creation, invention, and exploration were intimately related to the conclusion. Popper (1963) argued deductive argumentation was one of several intellectual and social tools scientists adopted to judge collective decisions. In Popper's description of scientific activity, all forms of arguments and evidence are valid in determining a fallible idea. Lemke (1990) argued logical

thinking was more a process of language than of intellect.

> ...We learn it [logic] by talking to other members of our community, we practice it by talking to others, and we use it in talking to them, in talking to ourselves, and in writing and other forms of more complex activity [problems solving, experimenting]. p. 122)

Rational arguments are "logical" only because members collectively agreed on certain rules to use in arguing. These rules vary within and between disciplines. As a result, arguments about biology may look very different than arguments about chemistry, even though they are considered "scientific."

Schwab described the differences between scientists' ways of thinking about the world:

> Some of the multiplicity arises because different canons of "truth," of "verification," are applied to different investigations in a given discipline. Many more variations of structure arise because men have conceived of many different kinds of "telling" questions to ask of their subject matter and each such question gives rise to a different pattern of experiment, different sorts of data, and different ways of interpreting data. (1961, p.243)

Differences among members' using arguments pointed to the connection between the social and intellectual realms of scientists' work. Discourse analysts (Lemke, 1990 and Michaels and O'Connor 1990) argued logic was a social convention, not simply an intellectual attribute, because scientists rarely work alone; they depend upon others to critique their arguments and, hence, conform their work to socially accepted standards. Ultimately, their arguments reflected shared intellectual social values.

As I realized the social context influenced the community's intellectual products, my job suddenly became more complicated. Now I needed to establish different arguments because students

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clearly did not value the same things as scientists, know how to use evidence in arguments, and know how to critically examine tentative ideas for their predictive or explanatory powers. In fact, some of the socially accepted features of school knowledge and the treatment of scientific ideas were counter to my goals. For example, many reforms agreed scientific ideas were tentative and that this was an important component of scientific activity.

> Students should learn that science corrects itself in many ways. They should also understand that early scientists whose work has now been superseded were not stupid, quaint, or primitive. Often false starts are necessary in order to eliminate the incorrect approaches. (California Framework, 1991, p.19)
>
> Students should be encouraged to challenge and reformulate observations and statements that are made about the subject at hand. The open, honest exchange of ideas must be as readily acceptable to the teacher as to the students [and their parents]. (California Framework, 1991, p.155)
>
> New ideas are essential for the growth of science--and for human activities in general...it should help students understand the great importance of carefully considering ideas that at first may seem disquieting to them or at odds with what they generally believe. (AAAS, 1989, p. 134)

These descriptions revealed points to the accepted value of guesses. However, my students' understanding of school knowledge was quite different. To them, guesses were inherently valued less than answers revealed by teachers or brighter students. Because I was the knowledge authority, students wanted to find out what I thought and tried to imitate the same knowledge.

While witnessing my students construct some arguments, I noted students who had better grades swayed others to their way of thinking, and some less successful students tuned-out altogether. Finally, if no one could come up with a defensible

answer they asked me for the correct answer. As a result, in this context, tentative ideas were quickly abandoned. What hope was there for sustaining tentative ideas in a social context where so many influential factors drove a school science mentality? How do teachers sustain scientific ideals contradictory to internal and external influences such as textbook depiction and standardized testing?

Little attention has been directed toward the differences of constructing arguments in varying social contexts, especially those as different as scientific communities and classrooms. As social issues influence scientific arguments, they also influence students' arguments. The differences between the social context of scientists' and of students' struggles should be explicated. But, unfortunately, science educators and reformers have not written much about these differences and little is known or understood about how students' collectively solve problems.

I had to get a group of students to practice something they did not know how to do. To teach them how to argue constructively in order to reach a collective conclusion, I needed to learn how they influenced one another, how their ideas influenced what data was used to argue, and how my expertise could be used differently. I was not exactly sure what this learning community would look like, but I was convinced arguments would help students *see* the world as scientists do.

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CLASSIFYING ARGUMENTS AS AN ACQUIRED DISCOURSE

Ultimately, what I needed to change was the entire social context, but what parts of classroom discourse help students acquire arguments and what parts impede such acquisition? For certain, two general areas had to change; we needed to treat ideas and one another differently. Because I wanted students to argue with evidence, and even though they would inevitably pressure me to give final approval to answers, I could not treat good answers as a final destination. Everyone's idea and vote mattered, so students could not bully one another or shut one another down. Therefore, I had to abstain from being the final authority, and the students had to change their social behaviors, if I wanted them to engage in the social construction of knowledge.

However, still, how do students acquire this type of discourse? How do community members learn to argue and in what context is this arguing process appropriated to others? Students needed to learn to pose their own warrants, make inferences and generalizations, and use data and backing to answer questions in a the context of science class with their peers at appropriate times.

Gee's (1987) explanation of how this social and intellectual process occurs was helpful for me to decide how to view and construct my classroom. Gee made two noteworthy points about how students acquire genre such as argumentative discourse. First, there was a difference between acquiring and learning a discourse, and second, students' social contexts and

relationships form their primary discourse that reflects their values and socio-culturally determined aspects of the ways they viewed the world.

The differences between acquiring and learning a discourse are investment, function, and oral practice in a social context. Acquisition is what we do when we fumble around to speak to someone we need to, perhaps for the first time. We acquire ways of speaking and acting to help us control our world. On the other side, learning to make conjectures represents more of the cognitive reflection, analysis, or final form of what constitutes arguments. Learning arguments from this perspective involves the ability to look at thinking from a distance and make informed judgments. In more detail, according to Gee,

> *Acquisition* is a process of acquiring something subconsciously by exposure to models and a process of trial and error, without a process of formal teaching. It happens in natural settings which are meaningful and functional in the sense that the acquirers know that they need to acquire something in order to function and they in fact want to so function. This is how most people come to control their first language. (p.5)
>
> *Learning* is a process that involves conscious knowledge gained through teaching, though not necessarily from someone officially designated a teacher. This teaching involves explanation and analysis, that is breaking down the thing to be learned into its analytic parts. It inherently involves attaining, along with the matter being taught, some degree of meta-knowledge about the matter. (p.5)

So, whether or not educators understood why or how speech events were shaped, they knew that what they did resulted because of the influences from their surroundings. In the case of argumentative discourse, acquiring a discourse that enables individuals to formulate a warrant was associated with the need to defend their beliefs, and the functionality or accessibility

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of their explanation relative to their peers. Gee (1987) pointed out that an argument assembled in a post-facto, deductive, and pristine fashion was a way to examine and learn scientific discourse, but practicing and mastering certain discourse patterns required a spontaneous-, push-and-pull-, in-the-trenches-type of treatment. Therefore, the arguments I wanted to instill in my students were aspects of a discourse they needed to practice in order to acquire.

Gee's second important distinction about how students acquire argumentative discourse raised additional questions about the course of action I should choose. He argued every body learned a form of "primary" discourse from their intimate circles, and this discourse enabled them to engage with the world in different ways. As a result,some groups find it more difficult to acquire a particular "secondary" discourse than others. This is due to the specific capabilities their primary discourse provides them because, "we are better at what we acquire, but we consciously know more about what we have learned." (1987, p.6)

Daily, scientists practiced a secondary discourse they acquired through their many associations, positions, cultures, and, simply, through trial and error. However, unfortunately, most of my students practiced a "primary" discourse that would not help them acquire the argumentative "secondary" discourse I desired for them. More importantly, I was concerned about advantaging some students and not others, and realized students

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excluded from class participation had little hope of acquiring this argumentative secondary discourse.

This concern disturbed me as I saw visions from Willis' description of the Lads and the Ear'oles (Willis, 1977). This vision portrayed students, Ear'oles, raised in homes where their parents thought about the world scientifically, or regularly built arguments as a matter of family decisions. The Ear'oles already acquired this argumentative discourse. But those, the Lads, who did not have this type of family interaction, never acquired the discourse in school. By trying to teach an argumentative scientific discourse I was in danger of exacerbating the differences among my students.

This premise brought back conversations I shared with parents of students struggling in my high school class who told me, "My daughter will struggle in your chemistry class. *I* could never get it." Those students who acquired this way of thinking, speaking, and acting from their intimate circle of adults and friends as a part of the primary discourse were not equipped handle the challenge of practicing this secondary discourse.

Researchers argued students could acquire a new--secondary--discourse, if the context was appropriate and recognizable cultural patterns were used (Heath, 1989; Delpit, 1988; Michaels and O'Connor, 1990; and Au, 1981). In addition, researchers described students acquiring new discourse forms in school settings and science educators established using tentative hypotheses as a part of interacting in the classroom discourse.

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Warren and Roseberry (1989) described their students not only acquired new ways of approaching scientific problems, they even applied newly acquired knowledge in their solutions. Warren and Roseberry even helped their students acquire a sense of the tentativeness in answers and, hence, changed their original attitudes about the nature of science.

However, the researchers and educators agreed one of the most important aspects of changing students' discourse patterns resided in the sensitivity of the teacher and the environment to their already existing patterns (Au, 1981; Heath, 1989; and Michaels and O'Connor, 1990). Therefore, a fundamental requirement for changing students' primary discourse into something more recognizable as science, was to find ways students already interacted and made connections to extend their already existing discourse.

> The key challenge for schools is to introduce and enculturate students into these school-based discourses, without denigrating their culturally specific values and ways of using language. (Michaels and O'Connor, 1990, p.18)

I had to create an environment in which students could readily engage in parts of argumentation as a form of discourse and be given the opportunity to try and fail. These students already had ways they made sense of the world and I risked denigrating these ways by promoting warrants and claims, and backing claims with evidence, so I had to formulate appropriate problems they could associate with their daily lives.

SELECTING APPROPRIATE PROBLEMS

Elbow (1986) described teachers exercising authority and called the process rationality. However, I did not want to "bamboozle" my students; therefore, I needed to create arguments without resolving them with a final verdict. But I was still uncertain how to resolve problems. My choice of problem topics could help me avoid this conflict of being the subject matter authority.

I already experienced students assuming teachers had the answers; therefore, if I continued to engage these students in arguments for which I had the answer, then the arguments were artificial. The triadic dialogue of the class broke all interactions into short, conclusive statements I used to evaluate whether or not students really understood the idea I tried teaching them. Jackson (1968) described the sense of distrust inherent in this set-up and how serving as the evaluator of all students' knowledge through classroom interaction is artificial.

Also, sensing this, I embraced Hawkin's notion of teachers and students trying to figure something out together (Hawkins, 1969). I looked forward to teaching my students when we shared the responsibility for discovering solutions, instead of expecting them to learn what was in my head. However, we were going to have to talk about different problems through different processes.

My students and I differed not only in what we knew (substantive structures), but also in the way we knew it

(syntactic structures). Ultimately, I wanted to communicate both structures in order to help my students see what I saw. However, Duschl (1990) would have suggested that I wanted to break away from giving them the correct answer, but I could not pretend not knowing what I knew.

> It is simply not sufficient to tell students our final form versions of what we know. Students must have some insight into how scientists "see." We have stressed again and again the importance of helping students understand how scientists have arrived at a particular stage of scientific knowledge. The path taken is not smooth. Nor is the final destination a simple concept. (p. 38)

So, I needed to find scientific questions that did not already have scientific answers. Duschl described using "fringe theories" to engage students in arguments about the larger and less established scientific ideas. In addition, he argued students could gather resources and argue about modern theories such as plate tectonics or cold fusion.

Reforms and Suggestions

Reforms recommended what students should be taught about argumentation. Reforms such as AAAS believed "science education should document the nature of such tensions from the history of science and it should help students see the value to themselves and society of participating in the push and pull of conflicting ideas" (p. 134). Students should be told stories of how scientists, once upon a time, changed their minds. So, students should be told about the science controversy, but the reforms did not specify how to engage them in the argument.

Unfortunately, reforms did not help me understand how students, themselves, could practice disagreeing using evidence

as a basis. The reforms did not consider aspects of controversy an acquisition of primary discourse, as they are not orally tried out, tested, and revised. The recommendations assumed because students were simply told how to disagree and how it once happened, they could apply the process to the outside world.

Few suggestions helped me decide what to do in my class. Given the existing techniques and facilities, finding or generating tests showing existing science theories was going to be difficult. Also, telling students about a controversy that occurred, once upon a time, was too traditional.

Researchers Suggestions

So, I reflected on all the research I read dealing with conceptual change. Driver (1983) argued teachers did not have to teach students about the major disputes in science history in order for them to use evidence in formulating arguments. She also suggested there was little need to investigate the possibilities, or accounts of past and present scientific theories being revised; a wealth of beliefs about the world that reside in students' minds could be the focus of meaningful interactions around tentative arguments about the world. If teachers would attempt teaching the value of tentative ideas advancing a network of reasonable beliefs, they only needed to look as far as their class to find a wealth of beliefs and potential theories to use in arguments.

Further, researchers such as Warren and Rosebury, and Anderson and Palinscar (1991) found problems and ways to engage

students in "rich problem spaces" where students were free to suggest tests, formulate arguments, and connect their knowledge to real world events. This method was consistent with the way I viewed acquisition and acting scientifically, and I realized the knowledge my students co-constructed did not need to be a contribution to the field of science to be useful. It was enough that the knowledge was new and useful to them and that I helped them investigate their own "wonderful ideas" (Duckworth, 1987, p. 12).

MY QUESTION, "SCIENCE FOR ALL?"

After my leave of absence to begin my doctoral work, I returned to my high school energized, confident, and filled with ideas of how to change my classroom so I would not feel compelled to give answers all the time. I had found some serious flaws and gaps in my thinking about science and I had a new sense of what it meant for my students to act scientifically. I began to invent ways to consider the social processes by which students could agree on a particular idea that was consistent with scientists' view of the world, but that also had merit in being socially driven by my students in a community.

I had bought into the notion that all students should learn science; I had a way in which I could teach aspects of scientific discourse reforms recommended. I had questioned whether the type of science I was interested in seeing from my students could be taught and I was left with an affirmative answer. But reform rhetoric left me with an even more

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encompassing question. Model reform documents (AAAS, 1989; California Framework, 1991; and Michigan Framework, 1991) called for aspects of scientific discourse to be learned by all students. AAAS was emphatic about its charge of "science for all Americans." My own experience led me to believe all my students could learn in these ways, but my experience, at best, was limited.

These reforms called for *all* students to come to know the world in these ways. I had never believed science was attainable only by the elite students and I was ready to test the charge of "Science for All Americans." This reform portrayed the interest of science educators,

> To reach all students means reforming the education of every strand of the student body--vocational, general, and college preparatory. For students who expect to go right on to work after high school, a narrow focus on trade skills will no longer do; they need to acquire a strong base of scientific knowledge and of reasoning, communication, and learning skills. All college bound student, quite apart from what they believe their majors will eventually turn out to be, need to enter college with an understanding of science...The recommendations in this report, therefore, apply equally to all students. (AAAS, 1989, p. 157)

I was convinced I could help my students acquire scientific discourse and there was no reason why all students could not. So, I wanted to test the charges of science for all Americans in a challenging classroom, to test these claims with a group of students who had not succeeded in science and help them acquire these ways of speaking, thinking, and acting that schools had never before helped them acquire.

Even though I agreed with AAAS claims that all students could acquire what I knew and that there would be conflicts in

the ways they acquired, I was aware that science, as embodied in the schools, often excluded certain cultural groups. I had read studies about how some student groups were limited in their achievement and acquisition of certain types of knowledge because of a clash in the ways in which they commonly made sense of the world (Ogbu, 1988; Heath, 1989; Au 1981; and Anyon 1981). In fact, the post Sputnik era of reform was founded on the mobilization of the elite students to learn science in ways that would help strengthen the nation as a leading contributor of scientific knowledge. The embodiments of this reform movement were highly selective and not very well suited to all students. The effect on science students was often stratification that coincided with cultural and ethnic differences (Ogbu, 1988) Such a result led researchers to conclude that school does little to promote an environment where new discourses may be acquired.

> In the absence of more objective criteria for what counts as a good text, or a good answer, teachers often work with discourse expectations that are personal implicit, privileging those students who share the same set of interpretive strategies and discourse assumptions as the teacher. If you don't come to school already controlling the elements of the discourse, it never gets unpackaged for you. (Michaels and O'Connor, 1990, p.24)

I did not want my class to be a place where their voices, and ways of speaking and knowing were downgraded. I was aware, however, of the nature of my mission. Gee argued that anytime people set out to change the discourse of another person, they risk demeaning or marginalizing the subject's discourse. In order to help my students acquire the scientific discourse, I had to change; I needed to expose the nonscientific discourse

and replace it with more acceptable conventions scientists use. Gee reminded me, however, that speaking conventions and discourses,

> ...are inherently "ideological." They crucially involve a set of values and viewpoints in terms of which one must speak and act, at least while being in the discourse; otherwise one doesn't count as being in it...Any discourse concerns itself with certain objects and puts forward certain concepts, viewpoints and values at the expense of others. In doing so it will marginalize viewpoints and values central to other discourses. (Gee, 1987, p.4)

Still, I was determined to find ways my students could succeed with this type of discourse. Teaching general education students would be more challenging than the bright, motivated, supported students I was accustomed to teaching. To learn the ways general education students argued and thought about science and to help them acquire argumentation with evidence as a primary form of discourse, I needed to be more patient and in tune with their lives. This acquisition process was going to be difficult because I knew we differed in the ways we thought about school.

Although I was not sure what those differences would be, I had faith in my teaching abilities, and understandings of the problems of constructing an environment sensitive to students' ways of speaking and sustaining the dialogue in which I wanted to engage students. The general education classrooms I had observed in schools were not ultimate places for students to learn new primary discourse patterns, and even though my class would be different, warnings from researchers such as Gee, still haunted me.

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> We must take seriously that no matter how good our schools become, both as environments where acquisition can go on and where learning can go on, non--mainstream children will always have more conflicts in using and thus mastering dominant secondary discourses. After all, they conflict more seriously with these children's primary discourse and their community-based discourses, and this is precisely what makes them "non-mainstream." (1987, p.10)

I was not aware of the specific types of difficulties my students would have. However, I was convinced I could not only specify what I wanted my students to do, but also create an environment in which each student would be successful. I had many ideas about organizing the class and how to respond to my students' attitudes, abilities, and dispositions. Developing a class was more than deciding the group of ideas to teach my students. My teaching approach was going to help change their perceptions about science in addition to the way they thought about learning. I could unpack how they would interact with one another and the subject matter. They could do acquire this new discourse. I included real-world objects and problems, asked them to consider their own personal beliefs about how and why things happened, had them design their own experiments to gather data, and had them evaluate, as a group, which explanation best described the events they witnessed. I could make a difference in the way non-mainstreamed students thought and talked about science.

INSTRUCTIONAL METHODS

Population

I was invited to work at Farmersville High School where Michigan State University (MSU) had set up extensive collaborative efforts. The science department here was familiar with conceptual change teaching and had a long history of cooperation with the science education faculty of MSU. Historically a farming community, Farmersville was now a bedroom community of MSU and composed primarily of white working class families. There was one class A high school that graduated 300 seniors a year, 50% of which go on to college. Farmersville required 2 years of each of the areas in English, Mathematics, and Science for graduation. I was not surprised to find a lower track science class at Farmersville High. Oakes (1985) described lower track classes exist in most of the schools of today and for most of the same reasons.

During the academic year, I taught *General Science,* which was comprised of students who had failed at least one other science class. This class I taught every day for 1 hour was out of the mainstream science track. My original list of students totaled 23, but only 18 showed up on the first day. By the end of the first week, my roster depleted to 19 because some of my students had dropped out of school for reasons including pregnancy, discipline problems, family problems, and other personal tragedies. My students had wide-spread attendance

problems, so class size varied on a daily basis from 9 to 17 students.

In a vein of extreme idealism, I volunteered to teach students who had failed most other science classes in which they had enrolled. Many of my students carried special education labels of some kind and the special education teacher I collaborated with told me that all of my students had learning disabilities, emotional problems, or both; my students shared a history of similar experiences in science classes laced with discipline problems and resistance. They were accustomed to being ordered what to do, but they were less accustomed to doing it. Regularly, my students displayed minimal self-esteem, ridiculed one another, and scoffed at school policies and procedures. These students had no other choice but to take General Science--this was their last opportunity to earn ample science credit to graduate from Farmersville.

Interviews and daily instruction enlightened me with my students' vast range of interests and abilities. Some of my students had been on special education caseload since the third grade. Some were new to the district and had problems with writing. Others were steered by counselors into General Science because of discipline problems, learning difficulties, or their need "learn the basics." Despite their complex and varied histories, all my students shared one thing in common--they all had flunked at least one science class at Farmersville High and they needed this class to graduate.

Instruction

I followed the recommendations of Heath (1989), Au (1981), and Michaels and O'Connor (1990) and tried identifying ways my students already discussed science. I began by giving them interviews following the protocol of Warren and Rosebury (see Appendix B). I videotaped nine students during the first week of class to learn how they approached science problems and to save the tapes for a future date when I could see the change in their formulation of arguments. Chapter 3 begins with a description of how we differed in our approaches to formulating arguments about the world (see Appendix C).

I learned my students' written work taxed them and most attempts to enable scientific argumentation through written word were more obstacles than facilitators. My students had difficulties putting complete sentences and coherent paragraphs together on a page, I decided the natural choice was that the bulk of the class work be done orally. This way engaged students in a sophisticated discourse and stood in contrast to traditional approaches of back to basics (Michaels and O'Connor, 1990).

I orchestrated class discussions around tentative ideas students posed and evaluated according to available evidence. I videotaped each of these arguments as well as some of the data from their laboratory experiments. To start off a given topic I would ask such questions as, "What does a battery do in a circuit that makes the light bulb light?" After a round of class discussions where students offered ideas, I sent them to

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tables to gather evidence to support their claims. After they gathered evidence, the students shared their findings with their peers. In group discussions, I promoted evidence as the key factor in evaluating any students' idea. The group also worked out rules for offering and accepting evidence. If they believed personal experience did not count because not everyone saw it, then they negotiated a compromise.

After all the data was made public, I asked students some extension questions their small groups had to solve. Each small group had to explain their conclusions and face their critics because I required a class consensus before we continued with the discussion. The group members were given license to refute models, offer qualifications, or decide more evidence was necessary before a class consensus could be reached. In this way, I could have them reconvene with the larger group, explain their solution to other groups, and then try to facilitate conversations around the ideas deciding whether students disagreed about the ideas themselves or whether some students were simply not acquiring the process of argumentation as well as others. I was trying to help them all try and fail and to use argumentation, and most often I came full circle to using evidence instead of some other more common ways to solve arguments such as student popularity.

While the students reassembled into a large group to discuss their findings and beliefs, I took notes about the ideas they promoted, what evidence they offered, and how I could correct some failing attempts to substantiate ideas by

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collectively using evidence. I also wrote for 1 hour after each class to reflect what had happened and help plan for the next day. In one of my journals, I tried to separate the discourse forms of inference from observation. This influenced how students talked about data. I wrote how their ideas conflicted and what I could do to correct faulty attempts at argumentation.

> I am having them draw posters and have them focus on what happened instead of what it suggests. For example, Samuel's poster began with, "The air makes it burn out quicker." We added that this was like the log (that Kristy had offered as a model) giving off fire and ash. They could (then) talk more about why (after separating what happened from what they thought). (Journal entry, 10/27/92)

Sometimes I would review the videotapes the same day to try to find what had gone wrong. I had entered the class hoping to get all of them engaged in discussions and acquiring ways of thinking, acting, and speaking that would help them succeed in ways they had never before. I would simply be helping students with their problems in understanding scientific discourse but their personal problems and histories confronted me idealistic way of viewing the class.

ANALYZING A LARGER SOCIAL PERSPECTIVE

In the following sections I add a required perspective of my students' participation and response to my efforts in the classroom. First, I explain what methods led me to consider these issues were relevant and how my struggles to discover ways to engage my students took me through unexpected detours of learning. Next, I frame why I reasonably expected them to respond the way they did. Finally, I reveal how my results shed

light on the inadequacies of viewing science education through generally accepted frameworks that omit important aspects of school-student resistance, such as alienation and disengagement.

The Social Context

I intended on stepping into the classroom and beginning the detailed work of structuring and modeling arguments around evidence. I anticipated, with the appropriate problems and environment, we would get right to the details of restructuring my students' discourse, which constituted warrants, supportable claims, and backing using evidence. Each teaching day, I kept daily journals with student comments explicating what they thought about school, logged sections of tape to understand daily incidents and obstacles, and saved and wrote about glimpses of my students' insights from tapes of class, interviews, and general comments trying to make sense of recurrent obstacles.

After completing teaching the first 20 weeks, I dove into my class tapes, teaching journals, and student interviews in anticipation of using these sources to pursue students' ideas. However, I discovered the sources almost always carried a more social tone. They focused on obstacles, inappropriate behaviors, and antagonisms between my students and school, and my students and me. Instead of keeping track of the progression of arguments, I was obsessed with implicit relationships between my students and school.

As a result, as an analytical tool to sort out the central points of each event I examined relating to their resistance, I

wrote stories. To maintain accuracy, I replayed and reviewed, my videotapes, and only after I was fairly sure the event was central to the recurring struggles we faced as a class changing discourse, I wrote and transcribed the events. To see how and what my students interpreted happened in the same event, I reread students' journals they kept throughout the term. As a result, these sources and using short story elements (main characters, plot, theme, background, and moral) enabled me to separate the main players and initiators from the followers, distractions from central issues, and my role of teacher from my role as story teller. These stories and their components identified the established and shifting social norms of the classroom.

I guided my story writing and analysis by interjecting the text with relevant literature from researchers who attempted capturing the social norms, treatment of knowledge, and how lower track students view their place in school. I learned many people wrote about similar problems and added insight about lower track students that is not mentioned in current reform or mainstream publications for science educators.

Lower Track Science

Many researchers studied such homogeneous groups as lower track students and agreed there was a distinctly different discourse and norms apart from the general student population (Oakes, 1985; Anyon, 1981; Eckert, 1989; and Willis, 1977). These researchers captured ways lower track students make sense of their school experiences and offered explanations for why

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students engaged in such discourse and how such discourse increased within the classroom environment.

These researchers noted some general trends about lower track students in science classrooms that include treating knowledge and response to school as a socializing authority, understanding school as having little to do with their lives, and not connecting scientific understanding to their lives nor considering it important to find any. So, learning was best characterized by diluting the content and focusing on easily attainable pieces of information and action (Oakes, 1985 and Eckert, 1989). In addition to treating knowledge differently, these students increased discipline problems in the classroom as well as with the general school policies. They had more frequent trips to the office, larger absenteeism, and confrontations with principals and other school authorities. Oakes reported this challenge of authority was one of the main factors that actually placed them in a lower track science classes and not their cognitive, innate, or actual abilities in school. Some manifestations of challenging authority ranged from direct challenges to directives given to students or to subtle negotiations with teachers in order to lower the expectations and press the limits of existing participatory structures.

As a result of these students' actions, teachers perceived these students needed more discipline or control, so they altered pedagogy to focus on directions and more explicit rules for class participation. However, this strict disciplining

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actually changed the nature of interaction within the classroom; the teachers treated knowledge as facts (Anyon, 1981 and Oakes, 1985). The roles of the teacher and student were even more influenced as teacher were found to encourage only questions that required factual answers, thus maintaining control over students by acting as the final authority over subject matter.

I wanted to break this teacher mold as final authority by engaging my students in a discourse that did not leave the teacher having correct, factual, and final answers. But, I struggled against forces closely related to their socialization and to students' content learning because the pedagogy they were used to, which focused on factual knowledge, drove our discourse toward a path of least resistance. My type of pedagogy--the discovery process--was necessary to change the root cause of students' resistance. Because, in fact, treating students as recipients of factual, fragmented knowledge increased the question of legitimacy of school with students and increased students' resistance and disengagement (McNeil, 1986).

McNeil wrote, "Ironically their [teachers'] attempt to minimize student cynicism by simplifying content and avoiding class discussion only heightened student disbelief of school knowledge and fostered in students greater disengagement from the learning process" (p.160). In other words, students engage with schools in ways best explained by continued skepticism and disillusionment with what schools can do for them, and with questions about the legitimacy of the role of school in their lives. While schools interpret misbehaving youth as a lack of

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control problem, McNeil argued scepticism and disillusionment are more fundamental reasons students resist.

In addition, the historical roots of this skepticism originated after the industrial revolution with introducing compulsory attendance. Then school was the prime social agent for socializing the "troubled youth." Reasonably, mature students who failed and never escaped the lower track, felt a greater illegitimacy of school control in their life and hence, resisted even more. As schools attempted to socialize and prepare students for their roles in society, these same students realized what their roles were and began rebelling. Apple argued making the school experience legitimate became difficult for some students and in order for schools to operate smoothly against such currents

> ...school needs to make all this seem rational...as if it were the only possible world....But...students, as they get older now verbalize reason with some facility, and can think through aspects of their social and cultural conditions. (Apple, 1979, p.83)

As a result of students' continual classroom experience that interprets the problem as one of control, the skepticism heightens and the pedagogy, instruction, and policies reflect attempts to keep students in line and to find a path of least resistance for classroom teachers and students (McNeil, 1986).

Internal Social Factors

Other factors drove the classroom discourse into polarizing the roles of teachers and students, causing antagonism. Steele argued there was a personal component of intentional separation individuals pursue when they interpret their contributions,

personal attributes, or background experiences being of little value. He explained students, struggling to maintain their integrity, purpose, and importance, internalize the failure of a pedagogy or the institutional message and, predictably, they reject their rejecters.

Apple expanded this argument to mention schools are actually structured to accomplish this stratification. Tracking and other school structural features were ways schools gave society's message, "It's your fault," to underachieving, unsocialized, or troubled youth. Therefore, schools were places where students were sorted and treated differently based upon their ability to be socialized. Apple (1979) wrote, "The form and content of schooling practices used to organize procedures such as tracking play a major role in encouraging students to internalize failure resulting from the stratification process as an individual rather than a social problem" (p. 94).

While Steele did not address the purpose behind the stratification, he did argue a reasonable response of students to such practices would be to devalue the institution that offered such criticism over an extended period of time, in a sense, an institutional rejection. Therefore, in an effort to reject the criticism devaluing who they are, these students begin a process of alienating themselves from school as an institution.

This rejection process continually threw out criticism to maintain their positive self-image. Students separated themselves from the mainstream expectations and from the

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authority figures trying to socialize them. As a result, students rejected schools to keep from blaming themselves for their school failure and hence, challenged teachers--the experts--, and resisted their socialization efforts.

Even though, at first, I interpreted my students' resistance as directed specifically at me and my efforts, their actions were really part of a larger context that included their alienation from school as an institution. Newmann described a process of alienation from school and offered that students feeling alienated would not engage in classrooms the way teachers or institutions expected them. Newmann characterized alienation as

> ...detachment, isolation, fragmentation, disconnectedness, estrangement, or powerlessness. These bespeak alienation....Alienation literature does not identify a single term to characterize its opposite, but if one term were chosen, engagement seems to capture many of this missing qualities in relations with people, work, or the physical environment. (Newmann, 1992, p.17)

In fact, Newmann (1992) treated alienation and engagement as antonyms. So in effect, their lack of engagement in daily tasks is testament to their alienation. My students' learned engagement/disengagement in school, and several blossomed into full alienation from their class and institution. Therefore, as a teacher and researcher, I not only had to overcome this predisposition of my students engaging in what I planned for daily activities, but also to understand how misunderstood meanings get perpetuated or thwarted within a social context in class.

I considered myself able to create and control the types of norms practiced in my classroom. However, while I assumed students would be receptive to the types of changes I promoted, I did not consider they might actively resist and partake in their own sort of alienation that took us away from acting out the vision of "science for all Americans." So, to better understand how their history or ways these norms propagate, I turned to literature about establishing social norms within a community or social group.

How Norms Propagate

Having identified a possible underlying rationale for my students' resistance, I sought to learn how group norms propagate. After all, I intended to break such habits and norms, and replace the classroom discourse with a scientific discourse, which does not necessarily use these same feelings of alienation. By spelling out how norms propagate, I would identify what role I played in initiating such actions and what struggles were inherent to the cultures, backgrounds, and students identities.

My reading what researchers believed about how norms propagate, raised larger questions. Hawkins and Weis (1985) argued the norms of deviant sub-cultures sometimes were established with and without teachers' help. Groups rejected by the institution socially construct an interpretation of their situation and its roots, which might conflict with the interpretations of the school.

Therefore, I needed to consider how students viewed school, developed and agreed upon norms, and how these norms played out in response to my vision of including them in the charge of "science for all Americans.". This alienated sub-culture operated by different rules from the rest of the school. Not only did they choose not to engage in the ways I asked them, my students were, and had a history of, establishing expectations and rules that contrasted or opposed the conventional expectations of the institution (Hawkins and Weis, 1985).

Student alienation spawned resistance where students rewarded peers for their non-compliance with teachers' expectations, or competition for grades or school recognition. As a result, their popularity increased by acting more deviant. What started as an evaluative sorting of skills or abilities to conform to conventional behavior (following rules, writing skills), escalated into the manifestation of a conflict of status within schools.

Hawkins and Weis argued this process of distinction perpetuates itself as groups strive to make their differences more prominent. For example, students associating with others also exhibiting unconventional behavior (deviance, back-talk) create new opportunities to engage in more deviant behavior (smoking groups, after school associations). Soon, rewards (humorous disruptions) are recognized among this student subculture for nonconventional behavior and this propagates more resistant behavior against the institution trying to change unconventional behavior. A factor that complicates this

socialization process is the general trend that lower track students rarely get reintroduced into the mainstream (Oakes, 1985). As a result of this consistent backdrop of rules, control, and discipline, students get increasingly proficient at these deviant norms, despite their schools' desirability or appropriateness.

Willis gave an account of the types of ways working class students get sorted, and carve out their identity in contrast to the teachers' expectations of model social behavior. While I entered class presuming my students were powerless and were subject to the stratification process thrust upon them by school, Willis (1977) described students acted with power and were active initiators of much of this anti-socialization process. My students' actions were not the actions of acquiescent subjects of the process, but often those of bold initiators of their own alienation from the school.

As in the case of Willis' lads, classrooms manifest class struggles in which teachers and students were primary players. This was a dynamic in which teachers and students were at direct odds. I had these types of struggles with my students. Until they entered my classroom, I did not participate in their tracking and alienation, but at the moment we engaged in a push and pull relationship in which my students tried to bridge their alienation while resisting my efforts to accomplish the same task.

The best construct for viewing this antagonism from the perspective of social norms and communities was the tendency of

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close knit groups to draw stringent and clear boundaries around their membership. This phenomena was not only described in literature concerning student subgroups (Eckert, 1989 and Willis, 1977), but also in the writing about scientific communities. Though the tools each group used to carve out such boundaries were different, the intents and results were similar.

Traweek (1988) and Eckert described groups using language and physical territory to define the boundaries. These boundaries were not always conscious decisions to conform to the accepted norms for the group. While high energy physicists used social exclusion, selected membership, and shared ideology, and space and equipment to define the boundaries of who were and who were not group members, alienated students made such decisions based upon fashion, deviant behaviors, physical school territories, and shared language. As an example of how language was a distinguishing factor of a social group, Eckert wrote,

> Perhaps that strongest evidence on the depth of the difference between jocks and burnout's lies in their use of language. There are obvious, conscious difference-the Burnouts' more frequent and public use of obscenities and of specialized vocabulary such as drug related slang. On a somewhat less conscious level, there are differences in routine expressions such as greetings....Grammar is a conscious marker of Jock and Burnout affiliation--both in recognition and in use. The burnouts are overwhelmingly seen as speaking "ungrammatically," that is, as using nonstandard grammar. (p.67)

Such boundaries were real and very evident, at least to group members, and clearly indicated members should act, not only within the group, but also how others outside the group "should" respond to them. Initially, my problem was that I was outside

my students' boundaries and ultimately, may continue to reside outside.

Overall, my students' interpretation of school was constructed in the shadow of their student sub culture and I was not sure what I did to initiate and propagate the existing norms I observed. Researchers explained that whether or not I tried propagating new norms or not, this was how this homogeneous group of students made sense of the entire school experience. In essence, they resisted me as an agent of the school, despite my intent to change their experience. School also strongly influenced these matters and whether or not I intended to change their norms and values, ways of interacting, or basically speaking, parts or all of their discourse was influenced by their perception of me as an antagonist or impetuous for counter-socialization.

Effects of Homogeneity

In constructing the class, I presumed a homogeneous group. Much of what I observed and read suggested my students and, in fact, all functioning groups were seldom homogeneous--regardless their selection of membership or socialization. There existed differences I considered part of the norms I set up for students to partake in around the notion of collaborative work.

Although group boundaries were drawn through members' actions and language, educators should not assume that any group such as immunologists, high energy physicist, and lower track students are entirely homogeneous groups. As I closely examined how each group operated, I discovered important characteristics

of inner workings and established norms that needed to be brought to the surface in order for me to understand my students' work. I chose to examine more ethnographic portrayals of science at work, not because they were more "true," but because they explicated factors shaping discourse as opposed to reporting a more historical perspective of its post-facto pristine products.

Throughout my analysis, I supported my writing by reading examples of scientific collaboration. I discovered parallels with the insider's perspective of scientists' work and the way my students interacted. For example, Traweek described how members established and maintained their status within a group of high energy particle physicists. Even though they anticipated that from such an intellectually regarded group status was independent of personality or social attributes, he reported that both attributes did play a role and cultures varied with how much age, personality, and other social factors affected particle physicists, and the ways they fiercely competed for status. Other portrayals (Latour and Woolgar, 1986 and Mayr, 1982) of scientific work supported Traweek's description that scientific competition and the establishment of status or authority were something other than promoting norms of rational, objective, unbiased, and pristine collaboration that were uninfluenced by race, gender, or culture. Social attacks, intimate alliances, and prior status histories often played prominent parts of getting a theory or explanation of data accepted as the rational or logical veracity of the data.

So, in the group, there existed a hierarchy of members and contributors who accepted, or mutually constructed hierarchies to determine who and what was discussed. In the reports of science in the laboratory, this hierarchy was influenced by social factors as much as intellectual attributes. In fact, in the case of high energy physicist, white male dominated discourse tended to predominate and direct the work of the field. One component of the way undercurrents drove products and interactions was members' willingness to practice bravado and self-absorbance. "This self-assertion and bravado is in part a matter of disdaining the work of others; it is necessary to show that one can and will expose mediocre work, no matter who has done it" (Traweek, 1988, p.87).

My students' discourse revealed ways an accepted hierarchy was established and maintained in my class throughout my study. They fiercely competed for status as well, but personal attacks, insults, or violence ended the competition. Invariably, males (socially gifted ones) led the discussions in the beginning of the study, but other social norms paralleled scientists' norms, and were established and maintained throughout. Within my students' discourse, they sorted out leaders, established communication norms, drew clear boundaries between their members and outside groups, and performed other social functions that revealed the functions of social norms observed in other groups such as close knit scientific communities.

PREPARING TO OBSERVE THESE ISSUES IN CLASS

These observations led me to shift my analysis to consider that what I really wanted was not necessarily a competitive free environment, but one that led to a collective and progressive argument as a product. Whereas, before, I considered the important distinction to make between my students and scientist groups was what they knew about the subject matter; but now, I focused on how to get these aggressive and competitive norms to work for bettering the community and its products.

As a researcher returning to my data with a new framework for making sense of events, I reviewed the videotapes, class notes, students' interviews, and students' reflective writings to unpack issues related to my students' struggles for status, agreed norms of interactions, resistance and alienation, and the process I confronted renegotiating such norms.

Sorting through my data, I recognized many of my students' attributes and attempted to find support describing my students as being alienated. As a result, I took events that most directly pointed to us being at odds with one another and developed short stories. To test the charge that alienation motivated their resistance, I presumed alienation led to their disengagement and attempted to spell out the group's norms associated with such feelings as isolation, disconnectedness, and other descriptors Newmann (1992) defined.

In order to study my students' social norms, accepted status, and ways of establishing pecking orders, I concentrated on my notes and taped student interviews after major fights,

squabbles, and attacks where I asked students why they would do such things to one another. At times I simply asked each student for their perception, but sometimes, to hear how acceptable it seemed to each of them, I recorded what they said both separately and in groups. I also required them to write personal journal entries about how they perceived the progression of the class or how they made sense of class issues, including events that divided them from the mainstream of school policy or practice. I needed, after all , to decide what aspects of argumentation and establishment of status shared commonalty with that of scientific communities as well as what was particular to this group.

Most importantly, I explored places we encountered conflict, and examined emotionally charged and gut wrenching events. I chose these events assuming they portrayed breakdowns in communication and explicated expectations of norms and values from each--teacher and student--perspective.

Finally, I turned to events where my actions were ones of re-negotiating the context in the ways Cobb, Yackel and Wood described. As a class, we began the school year with distinctly different ways of thinking about expectations of social interactions. We changed these social interactions through a re-negotiating process in which we made progress in constructing knowledge that led to shifting the products of the community. In chapters 3, 4, and 5, I share my data explicating specific problems of re-negotiating the social intellectual context of a community and the shifts of the products of this community as

well. It is a story of which I shape an alienated lower track science class through negotiation, establishing rules, and renegotiation.

CHAPTER 3

OVERVIEW.....86

ENGAGING ALIENATED STUDENTS.....86

PREPARING TO TEACH.....88

Interviews.....88

Instruction.....89

MY EFFORTS TO ESTABLISH SCIENTIFIC DISCOURSE FAILED.....91

Peer Criticism.....91

Side-Talk.....94

Disagreements about how to resolve arguments.....96

DISCUSSION.....102

TAKING A STEP BACK WHO ARE THESE STUDENTS?.....106

Just Another Monday?.....106

Class Conflict.....109

Planned Response Against Socialization Agents.....113

Extended Distance.....115

Teacher-Immersed Conflict.....120

Arbitrated Disagreement.....122

DISCUSSION.....125

ALIENATION AFFECTED MY STUDENTS.....127

DISCOURSE LEARNED IN THIS ENVIRONMENT.....130

CHAPTER 3

Shaping a Science Class Through a Series of Negotiations

"What is this Yerrick, science or a self-help class?"
- Brent

OVERVIEW

This chapter does more than present the story about how my students and I fail to establish the types of discourse I intended. This story focuses readers' attention on the aspects of conflict and change that stretch beyond the relationship of science into my students' lives, ventures beyond recommendations for effective practice, reveals my oral interaction and struggles to negotiate a classroom environment, and portrays my students' struggles coming to understand school and how my resistance to my efforts can be better understood. As a result, this story brings to light how my attempts to engage my students brought to the forefront their perceptions of what school had to do with their lives.

ENGAGING ALIENATED STUDENTS

Engaging students' attention is challenging, but this task is even more difficult with students who have historically struggle in school. One reasons engagement is more difficult is because failed students are placed in classrooms filled with other similar students an skepticism of what compliance can really get them increases.

Newmann (1992) explained disengagement results from alienation, and argued promoting engagement requires overcoming two major hurdles--authenticity and membership. *Authenticity* of school work must be the basis of learning. Teachers must give students the opportunity to construct their own knowledge, giving them some control and options for making knowledge authentic and useful in their lives. Second, school *membership* must be solid and understood; school membership involves clarifying purpose, fairness, personal support, caring, and success. According to this description, all students are not school "members" simply because they attend, but rather they have various memberships that entitle them to different school opportunities.

Presently reforms presume engagement as a starting point for changing science instruction. But many students' disengagement is a direct productof their school experience. Regardless of how teachers try to make learning more authentic, Newmmann warns that pursuing engagement without considering student membership leads to further alienation.

> Well-intended teachers, unaware of how students' social backgrounds affect their approach to schooling, may misinterpret their behavior. Organizational routines and curriculum mandates can reduce possibilities for authentic academic work. When the culture of schooling preoccupies itself with the maintenance of order, or competitive individualism, it deprives many students of a sense of membership. (Newmann, 1992, p. 34)

Engaging alienated students in school activities and academic work involves more than making subject matter more clear or interesting because engagement is a process dependent upon the students' perceptions and identity in school.

So, what do teachers do when students do not engage in constructive ways towards teachers' intended outcomes; when students' strongly held values conflict deeply with teachers'? How do students' memberships affect teachers' efforts and, conversely, how do teachers' approaches impact the ways alienated students think about school?

PREPARING TO TEACH

At the beginning of the school year, I tried to get a handle on the types of discourse my students used in order to make sense of the world. As a result, I anticipated their arguments varied from individual problem-solving and group discussions and attempted to capture long term individual changes as well as gain insight into the effects of social influences on argumentation by using interviews and instruction.

Interviews

First, interviewing a large number of my students taught me how they individually constructed arguments. I used open-ended questions to map the ways I thought their discourse use differed from what I envisioned and to develop some instructional strategies. From students' responses I discovered major differences in the ways I wanted them to argue and use evidence to formulate the tentative answers. (A complete report on the findings of these interviews is given in Chapter 5.)

There was little flexibility in their thinking about scientific answers because they thought science had final answers to most problems and these were the final word for

interpreting the world. As a result, if my students did not "know" the answer, they simply gave up and did not attempt guessing because, I suspected, traditional instructional methods taught them textbooks and teachers did "know" the answers to scientific questions. Their answers reflected a concrete set of ideas used to interpret the world that conflicts with the tentative answers I associated with being an expert scientist.

Another distinction in the way they used discourse was my first solid data revealing how alienated these students were from school and scientific discourse. Because my students thought "right" answers existed to the problems I asked them, but only others--experts--could find the "right" answers, they reeled away from delving into problems to find out the conclusions themselves. Instead, they answered in ways I interpreted as a powerless attempt to make informed decisions about finding-out because authority prevailed over answers.

I anticipated designing tests and interpreting evidence would be a struggle for my students. But, basically, I discovered my students' scientific argument, at least the way I thought of the process, was not a part of their daily lives. When pressed, they failed to guess at possible answers. There was only commitment that there was an answer and someone else could find it. I had to change the way they came to a response.

Instruction

I used whole class instruction as the venue in which to try to change my students' treatment of science. I wanted to promote a discourse in which students put forth tentative

solutions, support their solutions with backing and reasoning, and provide evidence and direct experience to substantiate their beliefs and reasoning. Ideally, if the group came to an impasse, I would resolve the conflict by clarifying the differences in a problem and offering new evidence to resolve the conflict. Therefore, the group had to accept the rule of whichever explanation fitted all the evidence and sometimes discourse about the problem remained open until everyone was convinced of a single explanation.

I began with open ended questions that I clearly marked for students as questions that could be answered in a several ways. Because I was interested in getting students to disagree and having them make their own judgments, I chose certain problems they were familiar with and I already experienced so that I could concentrate on supporting dialogue about conflicting ideas. These problems allowed several students to reach a conclusion and then present and support their conclusions before the class. In order to sustain the class discourse, I needed to help them express themselves and examine different problems using experimental data, and then they examined their own types of problems as a class.

I presumed my students would engage in arguments because I asked them to or because the arguments were more interesting than textbook explanations. However, the more I asked them to argue and propose tentative answers, the more apparent it became that we differed greatly in our recognition of what a science class looked like.

The difference in our class expectations resulted in the failure to change the discourse patterns in my class. I believe most of these differences were related to their failure and subsequent alienation from school. Ultimately, these failures directly led us to negotiate how the class would operate and what our roles would be.

MY EFFORTS TO ESTABLISH SCIENTIFIC DISCOURSE FAILED

I noted three types of failure to engage students in the types of discourse I wanted from my class that seemed particular to the group environment. These included struggles with 1) peer criticism, 2) side-talk--limiting the scope of discussion topics, and 3) disagreements about how to resolve arguments. After giving examples and elaborating on each of these, I will introduce three major themes or agendas that emerged to frame such breakdowns in a larger school context. While events of peer criticism, side talk, and disagreements about resolution were recurrent and often predictable, these larger agendas treat classroom events as less fragmented and more complex--more realistically portraying classroom discourse as simultaneously influenced by a number of student interpretations woven throughout each event.

Peer Criticism

One of the failures in achieving this type of argumentative, secondary discourse was sustaining ideas initially viewed with skepticism. Many times students were shot down by ridicule, or left out of the conversation by peers

ignoring them. As a result of an instance such as the one below, we agreed upon an initial set of rules.

1	Tr	*Okay. We're all in agreement about that part. Now where or what gives the force to slow down the cart? Friction, gravity, what?*
2		*(Several hands go up)*
3	Erin	*The rotation of the earth's rotation?*
4		*(Class laughter)*
5	Micah	*(jokingly to Samuel) Don't rip on people! (Referring to class rules written on the wall)*
6	Samuel	*(still laughing) You were laughing too!*
7	Tr	*Why are you laughing at her?*
8	Samuel	*I don't know.*
9	Tr	*(to Erin) Doesn't that make you feel like 'Gosh, it must have been a stupid answer when someone laughs like that?*
10	Erin	*Yes.*
11	Tasha	*Number five of the class rules.*
12	Tr	*You shouldn't laugh at people.*
13	Samuel	*I'm s-s-s...If you [Tr] wouldn't have made a big deal of it she wouldn't have done nothin'. She would have...(makes a shrugging gesture)*
14	Tr	*I know. I just want to set a precedent that regardless of what the answer is, we shouldn't laugh.*
15	Samuel	*All right.*
16	Erin	*The earth is rotating well...(mumbles something, becoming more quiet and then says) Never mind.*
17	Tr	*So tell me why that would exert more force on the car that is heavier?*
18	Erin	*I don't know.*
19	Tr	*Okay, We'll leave that as a possible answer. We haven't shown you right or wrong. But there might be a better explanation. There might be.*
20	Erin	*Yeah.*
21	Samuel	*(in a sarcastic tone) Oh I don't know. I don't think there is. That's a pretty good one Mr. Yerrick.*
22	Tr	*Samuel.*
23	Erin	*(recognizing Samuel's tone) Don't cut on me!*
24	Samuel	*(laughing) I'm not!*
25	Tr	*Okay here's how we could do this [disagree] differently*
26	Tasha	*Maybe it's...*
27	Tr	*Now someone might. Now this is how we might do this [disagree] in a different way. Some one who can support their explanation like gravity or friction and give a reason might be listened to a little more often.*

28	*Tr*	*(acknowledging Tasha's raised hand) Yeah go ahead.*
29	*Tasha*	*It just might be cause it's lower to the ground.*
30	*Samuel*	*(snickering and lowering his head to regain his composure)*
31	*Tr*	*Samuel.*
32	*Samuel*	*I'm not.*
33		*(class laughter.)*
34	*Samuel*	*I'm not!*

I anticipated an explanation would be less supported than others and would be discarded. However, what I did not expect was students treating one another's' tentative guesses rudely on a regular basis. The social leaders of the class such as Samuel exemplified discourse patterns that were in opposition to my intentions (6,21,30) and in which socially constructed norms such as feeling embarrassed about wrong answers consistently prevented open discussions from occurring. Students were getting clear messages from the intonation and non-verbal clues from their peers of how vulnerable students were to criticism in this environment (4, 5, 6, 16, 23, 30). Working against the undercurrents of this social context, I tried supporting all students' ideas and working them out publicly by using data. However, in the other camp Samuel tried to help me understand that if I did not confront him, everything would be "normal" (13).

Directing discourse in this way put me in the position of changing more than their treatment of ideas; I needed to change their interactions with one another. I did not have a good sense about how they interacted outside my class, but I did hear from them that they have been in the same classes together for some time and had already developed some contentious and

adversarial relationships with one another. I was intruding in their personal relationships where they made sense of their alienated school sub-culture.

I attempted to get them to practice conventions that ran counter to their beliefs about their peers by teaching them another way to investigate ideas. In this process, I needed to also show them everyone deserved a chance to be heard and stressed that no idea was "dumb." Finally, while showing them that proving somebody wrong did not mean out-shouting them, I explained to them how to talk, compete, cooperate, and respect one another's ideas.

My ways of using discourse starkly contrasted with what they expected from one another. Their alienation from school and from science made their participation seem appropriate and my behavior novel. So, my attempts to sustain conversation around ideas that seemed obviously wrong was met with confusion. Students asked me, "Why don't you just tell us the answer?" Brent went even further as to ask me, "What is this, Yerrick, science or a self help class?" Apparently, my actions reminded him more of a group therapy session than of a traditional science class he recognized.

Side-Talk

Another type of opposition to my establishing a productive argumentative discourse was students' tendency to talk about other conversation topics with their neighbors instead of listening to what was being discussed. Sometimes their side-

talk became so loud that I stopped class discussion because I could not hear what a student said.

Side-talk is a common struggle for most teachers, but it was especially problematic for me for two reasons. First, my students' paying little attention was brought on by a deep skepticism of the entire school experience. As a result, these students were much harder to reach than others who were at least somewhat concerned about their grades. Second, side-talking directly thwarted my attempts to have students consider opposing opinions--opinions that were central to my pedagogy. If my students did not hear the substance of what another student stated, they could not use the evidence to argue about who was right. Instead, I had to repeat, restate, or create a visual (poster, diagram) to clarify material that attracted all students into the discussion. My response defeated my purpose to having students state their own ideas because they would only listen to how I restated the explanation and not to their peers.

During one of the class discussions, Cindey and Samuel, two of the very socially skilled students, were whispering in the corner of the room when their private conversation finally interrupted the course of the discussion.

35	*Tr*	*How about digestion? How about the chemical change that happens in your stomach. Would one of these flag...*
36	*Kristy*	*Gas! Yes!*
37	*Tr*	*(laughs) That's true.*
38		*(Samuel and Cindey's continuing private discussion gets suddenly louder)*
39	*Samuel*	*It is true.*
40	*Cindey*	*No it isn't.*
41	*Samuel*	*You're shallow.*
42	*Tr*	*(Stops talking, looks over to Samuel and*

		Cindey, Long pause as if to signal class has stopped)
43		*Samuel...Cindey.*
44	*Tasha*	*(getting his attention) Samuel...(inaudible)*
45	*Kristy*	*(Nnt recognizing the pause) Smell from gas.*
46	*Tr*	*(to Cindey shaking my head and pointing) You sit here. First of all...*
47	*Cindey*	*I'll be quiet.*
48	*Tr*	*Well that's the third time I've had to ask you today.*
49	*Cindey*	*I swear to God. I'm not going to talk anymore.*
50	*Tasha*	*(to Cindey her neighbor) He loves us around here...*
51	*Samuel*	*(interrupts Tasha) SHHH! Listen!*

As this situation exemplifies, confronting students created opposing forms of discourse in my classroom. Cindey and Samuel assumed if I did not call upon them to answer questions or participate directly, I did not mind their talking about something entirely different (38). In contrast, I expected all students would listen and participate in discussions simply because I thought it was important and interesting to discuss chemical changes.

As I confronted them, Cindey took responsibility for the inappropriate talking, and counter offered my reprimand and demanded with a vow she would not talk anymore (47,49). As before, with class expectations, students negotiated with me for what my response should entail. Unfortunately, regardless of the responsibility, apology, and final submission, class discussion was interrupted a third time by a single individual without concern for the rest of the class or my intentions.

Disagreements about how to resolve arguments

So far, the failure examples are directed towards more general aspects of school. Next, I argue that students'

resistance to my pedagogy was intentional; some parts of their discourse involved actions that diverted everyone away from specific learning strategies I tried to implement. On several occasions, arguments erupted into personal slander, attacks, slurs, claims of expertise, or digressions of how to fight fair, so I established certain rules regarding how to argue. I realize ignoring teachers happens occasionally and has little to do with learning science, but the next example presents how my students deliberately tried not to learn what I asked them to and how, afterwards, they thought the encounter was funny.

I proposed four alternative designs for a monorail and asked students to choose a defensible design to present to the rest of the class. I intentionally fixed into the problem monorail specifications directly challenging the Aristotelian notion that objects naturally slow down without needing any frictional forces applied to the object. Within the problem framework, if students misunderstood the inertia concept, they were unable to agree with another group's design. Thus, if students believed that objects remain in motion indefinitely without frictional forces, some groups would have to argue against the need for certain craft features (emergency wheel).

However, Cindey attempted to change the problem by combining all the features so the craft would have all the special tools of both designers and therefore, the class could not argue. Unfortunately, she was not talking about the scientific problem; she wanted to have all the features and be right in the process.

Her group members knew this; Cindey wanted to give a separate answer from her group.

52	Tr	Now, Cindey you were in big disagreement.			
53	Samuel	Yeah, come on Cindey! (Anticipating revenge for prior attacks on his ideas.)			
54	Tr	Be polite. Stick to the explanation, not personal attacks.			
55	Cindey	Can I give my own answer?			
56	Tr	Actually, just ask him some questions. Why don't you agree [with Samuel]?			
57	Cindey	Well, the reason because number four you could put an emergency wheel on it...			
58	Samuel	Yeah, but there's not an emergency wheel on it.	59	Cindey	He said you could put one on it.
60	Micah	He said pick one or the other.	61	Cindey	Right, but then if you have to stop, it's gonna start right up.
62	Samuel	Okay, put an emergency wheel on it....Go on.			
63	Brent	Why would you want a spring on it?	64	Cindey	But, what I'm saying...
65	Mark	Why would you want a spring on it if you already had a wheel?	66	Cindey	Excuse me, I'm not done!
67	Kristy	But, like you said...			
68	Samuel	Okay, then let's say the spring has a wheel and a spring.			
69	Samuel	That's what you're doing, you're changin em! You can't just change the whole thing!	70	Cindey	No I'm not changing em, but the little spring is gonna push...
71	Brent	Fine! Then the one with the spring has an emergency brake and...	74	Tr	All right, I think... Cindey, I think...
72	Mark	What? The other one has a different base on it?	75	Cindey	That's why I put an emergency wheel on it.
73	Samuel	But, what if it has to stop though?	78 80	Tr Tasha	Cindey is actually... You're trying to say...
76	Micah	I think...	83	Tr	Yeah, That's right.

77	*Mark*	*You ought to be a politician.*			
79	*Samuel*	*She's trying to fix it so...*	*86*	*Tr*	*Yeah.*
81	*Mark*	*Politician.*			
82	*Samuel*	*...Trying to put something on that can't be there.*	*89*	*Tr*	*Right.*
84	*Brent*	*She's just trying to...*			
85	*Samuel*	*She's changing the problem.*			
87	*Brent*	*Yeah.*			
88	*Samuel*	*You can't do that Cindey!*			

Cindey's classmates accepted the rules of the problem and were willing to play by those rules (60, 67, 88). However, when Cindey violated the rules by incorporating all the special features and by successfully avoiding the issue of whether the monorail slows down without friction, her adversaries quickly clarified the rules of argument (60, 67, 84, 88, 89). Others argued using her newly invented rules (62, 71, 73, 80). Of the four options from which they were allowed to choose and defend as a possible solution, Cindey created option five (55, 85). As a result, another student ridiculed Cindey for not taking a position and called her a politician (77, 81). It no longer mattered what evidence could support one side more than the other; all that was important was that Cindey was wrong. The whole incident exemplified arguments were fought to win, regardless the cost.

When Cindey realized she was unable to convince the others of her approach, she remained in a strong hostile stance (66) and resorted to raising her voice and forcing her opinion. This

altercation ended with Cindey yelling to defend herself against the majority of the class. I recognized the confusion and my failure to establish productive argumentative discourse. I was working against strong forces and already established patterns. When I witnessed Cindey look up at the ceiling and shout, "I don't agree!", I interceded and asked everyone be quiet.

I asked Samuel, who had stood in front of the class for his portion of the presentation, "Could you come have a seat?....[Everyone] take your journals out for a minute....We're going to complete this [discussion] tomorrow, but I want you to write about [what just happened] first."

I distributed a handout presenting how to disagree and had them write about what steps could have been taken to avoid such a disruptive confrontation. Reading their impressions of this day's event was helpful for me to understand what went wrong in this discussion. Most student responses were critical of Cindey and emphasized the need to keep to the problem at hand.

However, the next day, when I showed them the videotape I used capturing this event, I realized I was up against strong social forces and there were rewards for ridiculing peers and challenging teacher expectations. I stopped the tape at the hostile segments. With their disagreement handout in front of them, I asked them to insert something from the sheet for an inappropriate remark they saw on the tape. I wanted them to tell me what could be done to disagree more productively. Surprisingly, they laughed at the hostile parts. They thought the confrontation was humorous. Unfortunately, despite

prompting other students, only one student tried using my type of discourse to correct what transpired.

What was carefully designed to be an activity and opportunity to argue about applying a scientific concept to a real world problem was ultimately a negotiation between students and myself about how to argue. Even the follow-up critique of arguments was met with mediocre response. Most students did not participate at all, but wanted to see the part again where Erin swore or where Cindey lost her cool.

I continually struggled with ways of achieving my goal to sustain discourse without major conflict. Through the inadvertent and antagonistic distractions, I tried to orchestrate arguments. This outcome was difficult work and demanded all the resources, advice, and moral support I could muster. My journal entry for this day began with the following:

> Today I felt the worst ever in the class. I felt like instruction was basically over the things that they were not wanting to resolve anymore and I started on a bad note....I started class feeling like things were not ready to go. I knew they disagreed about whether the monorail would slow down or not and whether it was important to get going...I should learn from this tape that they are not talking to each other much about the problem...I attempted to help them make sense of it by (returning to and) using balanced and unbalanced forces. It did little good. I emphasized that using the concepts that I have taught them would be important, but I cannot expect that they will do this simply because I mention it once or twice. I will need to show them that using science concepts that the teacher recommends is a useful tactic (to solving problems).

I struggled with the realization that my students easily grew tired of talking about scientific concepts. Scientific discourse was another reminder of the school from which they were working to separate themselves. In addition, I tried

teaching them how to argue and this was something they already practiced because arguments and hostility were a regular part of their life outside of school. They did not need someone like me telling them how to fight fair.

These failures in productive discourse, compounded by correcting students often, resulted in squelching individuals and discussions altogether. Regaining their cooperation was difficult for me. These students' regular response was to entirely discount criticism from school authorities. Abstaining from participation was a typical student response that communicated such thoughts as "I don't care what you think. I'll show you that you don't matter to me by ignoring you altogether." In my students, withdrawal from correction led to continued failure. Our responses placed us directly at odds with one another, and the classroom turned into a battleground where social classes predominated.

DISCUSSION

What I anticipated as a process of fine-tuning scientific arguments turned into gross misunderstandings and renegotiations concerning the social and intellectual context of the class. With the patchwork of social interacting, modeling, and intervening, I completed in daily conversations, Brent's question, "What is this Yerrick, science or a self-help class?" brought new insight to the nature of my creating this discourse community.

Each incident reminded me I am dealing with individuals who have a strong sense of how to act within a peer group.

Therefore, much of what they understand as appropriate was counter to my intentions. But what I learned about my students was that certain "work" was accomplished within this group through their discourse--work that had agendas associated with it that was consistent with their intentions and not necessarily my own. Included in the discourse of my students were three separate agendas my students pursued: 1.) to establish a pecking order according to their own recognition system 2.) to direct what was accomplished or the "work" of the class and how it would be done 3.) to draw clear boundaries between members of their group and others outside the group that included school officials and the majority of adults. In most events I analyzed and, indeed, all the events I include in this dissertation, two or more of these agendas are being pursued by my students simultaneously. For example, Cindey's argument with the rest of the class was influenced by two agendas. These were the group's needs to establish the rules all members follow (79, 84, 85), and to establish a pecking order of who should be heard (77, 79, 85).

As I examined this breakdown and other events that came in the way of the discourse I tried to promote, I discovered students were using their own understood group discourse to actively pursue this subset of agendas. These agendas, though implicit, unexplicated, tacit, and esoteric, seemed quite reasonable to them as evident through their responses to my trying to "fix" the problem. Students saw little problem with criticizing one another in establishing a pecking order. As I

asked them about why they treated one another like they did in Cindey's argument, they responded, "It isn't nothin'." They figured other students knew what they meant by the stabs and ridicules, "Don't worry about it," Dimitri informed me. Dimitri, Kristy, Dave, and Samuel told me they had been together in the same classes for years and this is how they always treated one another.

But my role as a teacher did not allow me to ignore ridicule, abuse, and rudeness to other students. First, it was not appropriate for them to treat each other in this disrespectful manor. Second, and more importantly, this behavior was counter to my instructional goals and methods. In order to focus on the type of learning I plan, I need to change the way they treat one another. In short, despite how they have come to understand their fellow students and school, I have to change the way they view my class socially and intellectually.

The discourse community my students and I envisioned were worlds apart. I presumed simply changing my teaching approach would automatically change my students' responses to learning. This was not the case. They did not know how to practice scientific discourse well, so the process was difficult, but they could not acquire it without engaging in it. But trying to engage them in a new kind of discourse caused much confusion.

My attempts to change these classroom discourse patterns caused many problems because my attempts to socialize them into my way of thinking was exactly what they had distanced themselves from the most. The third agenda--drawing boundaries

around themselves and separating themselves from adult influence--was an integral part of their classroom discourse that hindered progress. I will devote the rest of chapter 3 to elaborating this agenda. I will further explain establishing pecking orders and rules in chapter 4. Even though, none of these agendas can be treated separately nor account for all aspects of our breakdowns, I will approach them somewhat separately through events I feel were primarily motivated by one or more of these agendas.

The next section of chapter exemplifies an extreme case of side-talk and, therefore, is a subset of a previous category of my students discourse. This episode connects the types of discourse categories I have explicated to the larger and far reaching agendas of student subcultures. I describe the most clear and startling incident that revealed to me where schools stand in relationship to students' lives. This section serves two functions: first, it introduces readers to social concerns my students considered paramount--issues quite different from the issues AAAS and other educational reform policy describe as central to teaching science; and secondly, and more importantly, this section exemplifies how my students sought to draw very clear boundaries around themselves, how their alienation motivated them to bring to the forefront their third agenda of placing me outside their group, and how these types of antagonism and problems are inherent to this arrangement. In summary, this next section of chapter 3 provides readers with an insight into the depth of alienation, into the inflammatory

nature of these students' resistance, and into the use of discourse to draw boundaries between them and school.

TAKING A STEP BACK: WHO ARE THESE STUDENTS?

Just Another Monday?

As the bell rang on one cool October morning, students staggered into the classroom coated with the residue from their weekend activities. Some sauntered in with their eyes lowered toward the ground as they found a place to lay their head. Some students wore leather jackets reeking of smoke from that one cigarette required to get them started in the morning. Other smells lingered in the air. Odors of unwashed hair, unbrushed teeth, and that same shirt worn Friday reminded me that my students had endured a weekend unlike my own. This was a typical Monday morning.

Despite resistance, I started class as usual. Distant looks in their eyes searched for a purpose to be here. While students sat at their desks, I began describing how we would accomplish a group task of developing our first concept maps. When I had students pair off and some in groups in three's, Samuel called out, "Mr. Yerrick, you should of seen Brent this weekend. He was *so* wasted." I sensed that this was an invitation into the my students' social lives, which I did not want to accept. I immediately paid attention to Brent who was the only one who did not pair off. Sitting in the same seat he chose at the beginning of class, he stared down at his desk.

(Brent ended up working by himself the entire hour, calling me over to his desk for help.)

Before I could stop him, Samuel began recounting how Brent passed out in a tub at a party hosted over the weekend. I interrupted Samuel to direct the class back to the task of completing their concept map and the topic was dropped--at least for another 10 minutes or so.

Even though Brent had a tough and impervious outer appearance, I knew he was concerned with what others said about him. So, as Samuel and Cindey began talking again about Friday's events, Brent watched and listened to their quiet conversation. Brent tried to interject what he thought had happened, but the momentum belonged to Samuel. His version of the story placed Brent, Cindey, and several others over at his house partying when suddenly Brent quickly downed a fifth of vodka, straight. Samuel captured the students' attention as he described Brent "hurling" onto the bathroom wall, passing out, spending the night in the tub, and being so unaware of his state that others picked him up by his hair without response.

I noticed how Brent took in all the commotion. I interrupted Cindey and Samuel, and asked them to work on the assignment without bringing the party up again. Brent made several statements to protect my opinion of him, "I don't want you to think I do this all the time," and "I bet you think really highly of your class now, don't you Yerrick?" Brent did not deny what was said about him, but I sensed he was uncomfortable having his actions discussed publicly. I did not

like having to take action to restrain Samuel and Cindey from talking about Brent, but once again, I asked Cindey and Samuel not to discuss the party anymore because I could tell it hurt Brent's feelings. Apparently, This rationale was a reason they thought was equally valid, so we negotiated a reason to stop the conversation. Cindey apologized for the interruption and told Brent she would not tease him anymore.

This event bothered me for several reasons. First, Samuel did not mind getting attention at Brent's expense. Also, I did not appreciate struggling to get his group to work on the class assignments. In addition, I did not want to know about this aspect of Brent's life because knowing about students' self-destructive behavior forces teachers into difficult situations. How could I live with myself knowing Brent put himself at a great risk of harm and I did not act on it? However, once I rationalized it was unkind and impolite to tease Brent in front of the class, the discussion was dropped.

This event seemed one students were content to drop once it was reported and gained some recognition; it did not interrupt class for a long period of time and I did not raise my voice or redirect class again. We struck a cord of understanding with one another, as a result, they empathized with Brent's position or at least followed my suggestion. I thought the issue was over.

I am not sure why I did not tell the office. I suppose because I negotiated a significant reason for us to stop the distructful discussion. Besides, this event seemed far less

adventurous than other situations they described to me over the several weeks we knew one another. Perhaps I believed the students exaggerated.

However, in retrospect, there were reasons to believe this story had real significance for those involved. Brent reacted immediately to the teasing and spent the class hour in a lonely, somewhat non-responsive state. I did not doubt something similar to what they described did happen two days before, but I did not know my role in reprimanding students for behavior outside school during the weekend. Also, it is difficult for teachers to know what parents do not know or what they condone.

My primary concern was that the discussion interrupted my class and made Brent feel poorly. I took care of these conflicts. Although, it does not seem I chose the responsible action; I let the incident go unreported.

Class Conflict

Soon after this class incident, I learned Brent's parents did not know he was drunk that Friday night. As a result, I made the wrong call in not informing his mother and some other school officials. To make matters worse, students implicated me as the person who told the school officials who called Brent's parents that Monday evening. However, I was unaware of the events that transpired in the next 24 hours between Brent getting teased and my students storming into class Tuesday morning making accusations of foul play.

Tuesday morning, Brent was one of the first students to arrive and he described to Dimitri how he might get thrown out

of his house for drinking. Dave took it upon himself to make a public announcement, "Mr. Yerrick told the office." Blind-sided by this volatile situation, I responded jokingly, "Oh, come on!" Suddenly, the class activities I planned seemed to be fleeting notions as students became increasingly involved in piecing together what had occurred. What emerged was an issue of breached trust and I was a key factor in resolving this issue. The accusation seemed to spiral out of control as students contributed their own concerns.

90	*Dimitri*	*What happened?*
91	*Dave*	*Mr. Y told the office.*
92	*Tr*	*Oh, come on!*
93	*Brent*	*I'm gonna be grounded for a real long time... I didn't think they'd call my house.*
94	*Erin*	*They called his house?*
95	*Cindey*	*Whose house?*
95	*Erin*	*I knew they would.*
97	*Tr*	*I don't think she (Mrs. King) knows much about it. She hasn't viewed any of the videotapes either.*
98	*Samuel*	*They call my house and I'll tell them off.*
99	*Marc*	*That's none of their business what we do on the weekend!*
100	*Kristy*	*It's not their business what we do off school grounds.*
101	*Brent*	*They'll kick me out of my house.*
102	*Samuel*	*Did they know where you were?*
103	*Brent*	*Mom said the school called. They said I was over at Samuel's house getting drunk.*
104	*Samuel*	*At Samuel Morehouse's house?*
105	*Erin*	*Sue him.*
106	*Cindey*	*They didn't call my house yet.*
107	*Erin*	*They don't need to be calling.*
108	*Kristy*	*It didn't happen last year...They asked me all these questions and tell you that you'll be anonymous. Well I'm not narcin' on all my friends.*
109	*Erin*	*Someone overheard it. It's so stupid. It's insane.*
110	*Kristy*	*It shouldn't be any of their business.*
111	*Marc*	*From 7:40 and 2:45 it's their business but after that is none of their business.*

I listened carefully to what they said. My students were in an antagonistic position against school policy. The use of the terms "we" and "they" (99, 100, 102, 103, 106-108) signaled the separation between the student members of their subculture and school officials implied as their adversaries. Another indication of the reiteration of established boundaries was the rejection of school as the authority over certain parts of their lives (99, 100, 105, 107, 110, 111). Each of these comments sought to negate any notion of the legitimacy of school to influence their personal lives. Most students appear unified in their extreme position of being alienated from school. Until now, I had never heard students talk so plainly and boldly about resistance to schools' authoritative role.

But more than one agenda was being pursued at this time as students were directing the work of the group as well. Students' discourse was establishing who gets to talk and what kind of talk should be propagated in this discussion. There were two students offering an occasional, "Well you were so open about it," and, "Well, why didn't you tell your parents in the first place?" These comments were lost as students interrupted the dissenting individuals and spoke over them in the mire of an emotionally charged majority sympathizing with Brent's position. Though the bell was about to ring and I was getting ready to start class, the group was actively seeking to influence what we were going to discuss for the day and who was going to be able to contribute to this conversation.

As my students continued to discuss this issue, emotions ran high. The more I listened, the more I realized my daily school experience and class expectations far differed those my students mentioned that Tuesday morning. Even though they seemed to understand exactly one another's position and complaint, I was lost in the scurry of issues tossed around. My students clearly defined boundaries of the areas schools were supposed to affect. One thing was clear; they generally agreed schools were only a part of their lives and should not step outside these boundaries the students set. Therefore, in their view, Friday night's activities certainly did not fall into the schools' jurisdiction.

I struggled to keep social matters and personal needs outside class because I wanted to gear towards talking about scientific topics, which I planned. I explained there was a real problem with Brent being out of control on Friday, that I was not sure how the office found out, and that I wanted this discussion dropped because the topic did not pertain to my goals in generating a scientific learning community. After quieting the riotous comments, we managed to work through the rest of the hour with some progress towards my prepared lesson plan.

One possible reason students discussed Brent's dilemma in class was because of my ambiguity. I was not a teacher they recognized and they were testing my limits for class discussions. Well established teachers might have immediately squelched the discussion from the beginning and even turned-in Brent.

However, this argument overlooks the essence of what traditional uses of control sought to accomplish--the denial of the chasm between schools and alienated students. My students were alienated and were acting on their perceptions. If other teachers who taught my students did not have trouble with their resistance, they only needed to visit the attendance office, disciplinary officer, or even the juvenile courts to see evidence of the extreme skepticism my students held of school. Although special circumstances brought on by my position as a researcher initiated this example of class conflict, other events surely could spawn similar issues equally emphasizing the differences between schools expectations of my students and my students' choice to alienate themselves.

At the end of this conflict, I was left to re-establish my students' membership to the school. I wanted my students to engage in class and put aside their differences with the school's general policies. As a result, I needed to find a way out of this messy situation and also find ways to prevent my students from instigating other events that would increase the distance between us.

Planned Response Against Socialization Agents

Regardless of how I ended up in this uncharted territory, I wanted to be free of the whole event. So, after class, I met with a special education consultant and we worked out a way to talk to these students about omitting their personal stories in an effort to talk more about science. We knew from interviews we previously conducted that social talk distracted many

students. Therefore, we wanted to limit these distractions in order to make a better environment for learning. Finally, we decided on the following 3 activities:

1. Explain they were receiving science credit for class work and I was responsible for providing opportunities to achieve this credit

2. Discuss their disapproval with the unruliness and distractions of social life

3. Initiate their activities enabling them to practice being their own advocates in keeping group conversations on task by having vignette students model and practice appropriate self-regulating conversation to deflect social conversations toward science talk

Our plan made sense. Student advocates participated in helping sustain better conversations about subject matter, and this responsibility seemed to correspond with the consultant's impression she received as a result of interviews she conducted about how the class was proceeding. I began the next class period with explaining I wanted to change the course of what was discussed in class. I began with,

112	*Tr*	*I've been dealing with this problem and it seems to be getting worse.*
113	*Cindey*	*Bad language?*
114	*Tr*	*No it's not bad language. I think you were swearing more in the beginning of the year than you are now.*
115	*Cindey*	*Not me! It was Erin. I'm not the one who swears.*
116	*Tr*	*I meant you in the general sense. It's about the way discussions go in here...*

I continued to tell them what I believed was our mission, what we were here for, and that side-talking kept us from completing work and goals. At this point, interested in their impressions, I invited them to comments on what they thought about my requiring them to talk only about science.

Unfortunately, they interpreted my invitation to discuss this topics as an opportunity to share what was most important to them.

Extended Distance

117	*Tr*	*Anybody else have another concern about the amount of stuff we get done?*
118	*Marc*	*We get a lot of stuff done. We got like almost the whole wall covered with stuff [concept map]. It's not just parties. It's not just from talkin' about parties. It's gonna happen in this class or it's gonna happen somewhere else. I go to this class and I talk about parties and I go to my next class and I talk about parties. I'm just waiting for you guys to call my house. I swear to god. My ma'. I dare you call my house.*
119	*Tr*	*Marc, you don't think...*
120	*Cindey*	*I still don't...*
121	*Marc*	*It's bullcrap ain't it? They ain't no reason ta tell what we can do outside of the school. It's our problem. It's our parents problem. It's not theirs. Ya' know, you don't expect to come to school and be on tape. I'm surprised they haven't taped us yet. It's not fair, man. It's just, you know, the school's problem is what we do in school. Cause it's not fair , man. Cause you know that between 7:40 in the morning until 2:35 in the afternoon. You know? If we come to school drunk, then you got something to worry about. If we don't, don't worry about it. It's our parents problem. I'm sure. My mom knows I drink, but she knows I'm a smart drinker. I don't go around I don't get drunk. I don't drive home. I don't get in an accident. I ain't dead. I know when to stop I know when to quit. So, why, you know, look at Brent, man. He's almost gettin' kicked out of his house 'cause someone told on him. What he does with his life, he's old enough, he's responsible. Brent you know when to stop drinkin'?*
122	*Brent*	*Yeah I think...*
123	*Marc*	*You know? You know? Everybody. I'm sure I'm sure everybody. I'm sure you've done it. I'm sure someone in this class has done*

		what he's done. Just, the only problem is that they didn't call your parents. Now, I'm sure that if someone would have called your parents when you were in school and did that, don't you think you would have gotten in trouble, too? You know, it's his parents' business in a way, and it's kinda his fault because he drank that much. It's his fault, not the school's fault and it's none of the school's business. That's how I feel about this whole situation.
124	*Tr Asst*	*I think Marcus that's a good point. And it's true for all of us. I mean, there are pieces of my life that I wouldn't care to share at school. There are appropriate places to talk about those things and maybe the school isn't the place.*
125	*Marc*	*At least he was smart enough to do it at someone's house and he stayed there. I mean he could have been in a car, out in the middle of a field, at a party, or out in a cornfield, (Brent, Dave, Micah snickering) with a keg, sitting in the back-seat. With the four of them. But its' not like that. He was at someone's house and responsible enough not to go home. Did you go home? Did you drive?*
126	*Brent*	*No.*
127	*Marc*	*I think you said, what you say? You slept in the bathtub? You se, when he gets up in the morning you just turn the faucet. The puke just runs down the sink. It ain't no big deal.*

The issues most important to me were only remotely related to the issues my students were ready to discuss. We were again working cross purposes as Marc and I were simultaneously seeking to establish different kinds of "work." I wanted to establish a set of discussions about scientific explanations and physical phenomena while Marc presumed that we ought to be talking about issues more central to the social welfare of the group of students practicing deviant behavior. The difference was that the issues the two of us considered central to our purpose were contrasted with one another. While I wanted to stop the talks

about parties and other outside events, students were seething about how school was the enemy getting Brent into trouble. I tried starting a conversation about limiting our discussion to class subject matter (116, 117). However, these students were not only resisting my efforts (115, 118), they were also taking the initiative to rise up against the injustice towards Brent (118, 123).

The ambiguity of my role and the uncertainty of how Brent got in trouble with authorities initiated another set of negotiations about the work of the class. At the same time and often with the same comments students were trying to establish the rules of how we should talk and get things done while drawing clear boundaries between themselves and the school--even me.

Ironically, both of us were looking for ways of not having to deal with their personal lives. Throughout the discussion, there were several indicators that they were using diversionary maneuvers to redirect class discussion towards their topic. Students inserted volatile and inflammatory comments instead of answering questions I directed toward them.

128	*Tr*	*Marc you mean to tell me that you don't think that the party conversations are getting annoying. Is that what you're trying to say?*
129	*Marc*	*Well the party conversation is what happened We talk about the party of Monday. We don't talk about it Tuesday. We don't talk about it Thursday. But one thing we do talk about is when we talk about it on Monday, his parents get a call Monday night! Ya know? It's kind of bullcrap 'cause I don't go around talking to anyone else's parents.*

* * * * *

130	*Tr*	*I want discussion to go in a certain way in this class, and that's really why I brought this up, because I want us to talk more about what it is we're here for and less about a lot of social things that are outside of class.*
131	*Dawanda*	*Yeah, but you can't expect us to ignore it. Like when Dave comes to school, like when somebody got shot at his party. (everyone jumps into the conversation)*
132	*Tasha*	*That was his own fault.*
133	*Marc*	*That was Dave's fault. That was stupid. That was a stupid party.*
134	*Cindey*	*That was Dave's fault because he put up fliers and stuff.*
135	*Marc*	*Dave got everything he deserved. He did not have to go out and pass out fliers at the mall.*
136	*Dave*	*400 of them*

* * * * *

137	*Tr*	*But you are involved in the discussion because at least two of your questions have been just dropped.*
138	*Dimitri*	*I think they should stay out of our business. It doesn't matter if we all get drunk or not.*
139	*Cindey*	*I talked to my mom last night and she doesn't even think it's right.*
140	*Dimitri*	*It's not. It's not right. It's not the school's business.*
141	*Brent*	*It's only Farmersville that does it. I talk to people at the career center. Nobody else ever...*
142	*Cindey*	*and*
	Dawanda	*I know.*
142	*Brent*	*...no other schools have that problem but Farmersville. It's a gay school.*

My students, like most students alienated from school, became experts at diverting open discussions against the current of teachers' intentions. Responses to each of these conflict examples show a pattern of students ignoring the intent of my question and fitting their responses to continue the resistant (118, 129, 131, 138). Students have acquired discourse patterns that lobby for other students' support to divert class discussions from teachers' intent. Comments following each of

these student's initiation reveal they recognize this discourse pattern as a call to arms and an invitation for the larger group to take control away from an individual representing a minority position (teacher, outside student) and place it into the majority's hands (139).

Students' blatant resistance to my subtle redirection and are manifestations of their separation from school socialization. My students were not only using discourse to direct our "work" they also took advantage of the situation to denounce the school and give indications they wanted nothing to do with it. While, I invited them to help decide how to stop the interruptions of our class, I did not invite them to disagree with school policy dealing with their personal lives. At this point, I regretted the openness I offered to them on other occasions and in other contexts.

So, I persistently tried getting students to recognize their resistance to my subtle redirection and their blatant misdirection of class discussion away from my stated intentions are manifestations of their separation from school socialization. While, I had invited them to disagree about interpreting evidence, I did not invite them to disagree with school policy dealing with their personal lives. At this point, I regretted the openness I offered to them on other occasions and in other contexts.

Now, I wanted to act in a more traditional way and simply convey to students, "You can interact about subject matter or you can choose not to interact. The choice is yours." Due to

the conveyed emotions, I believed whatever the issue, resistance would increase if I continued plowing. Continuously, I tried getting students to recognize my agenda by redirecting the conversation and telling them this incident was not related to our class events. We took care of the conversation and distractions in-house and I was not involved. However, I was about to be positioned where I thought I had protected myself--shielded from their personal lives.

Teacher-Immersed Conflict

143	*Tr*	*Brent, maybe this would be an appropriate time to tell Marc what happened had nothing to do with the conversation in class.*
144	*Brent*	*Well I don't know that.*
145	*Cindey*	*Yes it did.*
146	*Dave*	*Yes it did. Yes it did.*
147	*Marc*	*How did his...How did his parents find out?*
148	*Dave*	*He said it first hour and she just...*
149	*Tr*	*Well she's not in here.*
150	*Brent*	*I just have one question. Does anyone else see those tapes besides you?'*

Suddenly, I was confronted with my place in the conversation. The students, at least Brent, Dave, Dimitri, and Marcus thought I had something to do with Brent's parents being called. I had heard other references to this trust issue,

- *"I'm not going around narcin' on my friends."*
- *"Well you were so open about it yesterday..."*
- *"I never said nothin'."*

and jokingly,

- *"Mr. Yerrick told the office."*

However, this time the accusation was direct and public. Had Mr. Yerrick stepped outside of the role he portrayed for the class? Did he tell on Brent so he would get in trouble and

perhaps get kicked out of school? All at once, they immersed me in this dimension of their social lives; I was not ready to deal with these moral threads of my students lives.

I had prepared myself to deal with students' misconceptions about science and their abilities to resolve intellectual arguments with evidence. Having taught class for only a few weeks, I was in no position to sort out these student issues. Even though I was certain I had done nothing to compromise my students' confidentiality, unexpectedly, I had to convince them I had not.

Then suddenly, as quickly as my test had arisen, it seemed to be resolved.

151	*Brent*	*I just have one question. Does anyone else see those tapes besides you?'*
152	*Tr*	*Never.*
153	*Kristy*	*Never?*
154	*Tr*	*Never.*
155	*Brent*	*All right.*
156	*Marc*	*And that's the only time, that's the only time he talked about it. Did you talk about it first hour?*
157	*Dave*	*Yeah, he said one thing.*
158	*Brent*	*Like one thing.*
159	*Marc*	*All right what happened? Did you talk about it the rest of the day bedsides this class?*
160	*Brent*	*No.*
161	*Marc*	*So the leak's in this class!*
162	*Brent*	*Basically, the leak is in this class.*
163	*Tasha*	*Probably Samuel.*
164	*Dave*	*Ms. King's fault.*
165	*Marc*	*It's none of Ms. King's business. It's none of my business. I ain't gonna call your parents.*
166	*Brent*	*It's none of no one's business.*
167	*Marc*	*Tcheh! (In disgust) Call my mom. I'm just waitin' for you guys' phone call. So's my step-dad.*
168	*Tasha*	*(to Brent) So keep quiet about it. (gets a smile and nod from Tr Asst.)*
169	*Tr Asst*	*Tasha, could you say that a little bit louder?*
170	*Brent*	*It's kinda hard when the person...(raising*

		his voice to talk over Tasha), It's kinda hard when the person...
171	*Tasha*	*Just keep quiet about it. If you wanna' get drunk over the weekend, there's no need to publicize it.*
172	*Brent*	*It's kinda' hard not to talk about it when the person who has the party is in this class.*
173	*Tasha*	*Well, you need to show some maturity too.*
174	*Marc*	*Its just ya'll relax, you know. You all take it to seriously. Like Brent's not gonna die of an alcoholic. The guy is smart enough to stay home before he can die. He's either gonna' pass out before he dies.*

I was not their antagonist. Feeling I could not enter the conversation and redirect their attention toward science, I tried to exert power in order to stop side-talk. Unfortunately, I could not accomplish this goal by using subtle cues to Dimitri or Marcus or by using declarative statements such as, "I want to talk about science in this class." This time, with greater authority, I once again declared my agenda.

Arbitrated Disagreement

Not surprisingly, no one paid much attention to my agenda and what I wanted to discuss. Frankly, I did not care how they worked things out with the assistant principal because I simply wanted a "normal" class. Wanting to do things differently, I made a statement capturing my urgency to drop the matter as well as introducing a negotiating chip. I spelled out what I would do for them and how it would benefit them, if we did not bring up such conversations again.

175	*Cindey*	*I think discussions do get out of hand in this class. But Another thing I'm saying is that if they don't want us to talk about it in class then maybe we should talk about it outside of class. The teachers too.*
176	*Tr*	*That there should be a forum for that?*

177 Cindey *Right.*
178 Tr *I'm all for that. I'm in...I'm in full agreement.*
179 Marc *He's the one that started it.*
180 Tr *I'm in...I'm in full agreement.*
181 Cindey *They shouldn't bring it in the class if they don't want us to talk about it.*
182 Tr Asst *I think that's a good point. I think that we should maybe just establish that starting today?*
183 Tr *I will...I will...*
184 Cindey *But it's already gone so far that there does need to be a discussion with him.*
185 Tr *Well, I understand that. So I will petition the assistant principal and say, ' you know it would be appropriate if at least 20 minutes a week you would meet with this core group because it's taking time out of my class.*
186 Cindey *Well, I don' think that a lot of us in here are going to drop it, this discussion until he comes in here.*
187 Tr *...then you should talk should talk about it. However,*
188 Brent *Let's just drop it. It's getting real old.*
189 Tr *I understand Brent, it is getting old...*
190 Cindey *It is getting old.*
191 Tr *...and Marcus said the same thing,' Let's just drop it.' I understand that. I'm not here to talk about getting drunk and who's right and who's wrong. I'm saying that it's coming in the way. That's all. That's all I wanted to say this morning and that's all I wanted to hear is a couple of option to get around it. Okay?*

192 Cindey *Just don't even talk about it anymore. Just start in on science when we get in here.*
193 Tr *Well, I certainly don't bring them up.*

Finally, I reduced myself to not solving all their personal problems and made a directive. Simply, I told them we were not going to talk about it anymore because class was not being spent wisely. I am not sure whether we were all tired of the topic at hand or whether students understood I wanted to move on with their lesson. Regardless, I emphasized what was to be discussed in class and clarified I was not interested in knowing certain parts of their lives.

Although it does not appear much of a negotiation, I must note three important aspect of this conversation. First, students were allowed to state their opinions and speak forthright about the injustices the school had promoted. Second, I promised to seek an audience for them to meet with the assistant principal. Finally, I suggested not to speak about these events, not simply for my benefit and limiting my interests, but for theirs as well.

194	*Cindey*	*"...obviously we shouldn't talk about this class because there's someone in this class that has a big mouth, so we shouldn't discuss it in this class."*
195	*Tr*	*Do you think an appropriate thing...Do you think that maybe a way to fix both our problems is, since I have a problem not getting a lot done sometimes on Monday...and you guys have a problem that security is a problem, so wouldn't it solve both our problems if we decide that we're not going to talk about this stuff in class?*

As an alternative for conducting the class, I directed a reasonable compromise that met both our needs.

I organized the class to give everyone the right to have their voice heard when making decisions about scientific ideas and evidence. I anticipated the students would cooperate and discuss at least my planned topic. I negotiated additional changes about talking to one another--trying to eliminate the criticism, the rudeness, and the dependency on other ways of arguing. However, what I had not planned on negotiating about was the class itself. Trust was not important to me. I knew I had not violated their trust, so my main concern for class was progressing towards thinking and getting scientific topics

completed. Still, my experiments with monorails, Ping-Pong balls, and frictionless phenomena were far removed from the areas of vital importance to these students lives.

DISCUSSION

There were several breakdowns in the classroom as I attempted to change the discourse used in my class. They had acquired ways of operating in school that were quite powerful and influential, although they did not do much to enhance or help them do what I asked of them. They were quite good at competing and arguing and at trying to steer class discussions in the ways they wanted them to go and to accomplish what they wanted to do. Our miscommunication seemed to be a result of students using discourse that was associated with a peer group alienated from school and how they attempted to manipulate influence and navigate and their way through it. Though the categories of side-talk, arguing to win, and peer criticism, capture certain elements of my students' discourse, they are better understood when framed in larger agendas contrasting their "normal" discourse in the context of classrooms. These agendas of competing for status, establishing or steering what and how the "work" of the group gets done, and drawing boundaries are threads that seem to weave through most of the talk and work of the class.

While separation seemed a major thrust in their resistance, they also met other agendas as well. My students actively pursued group status as well by promoting stories and bravado about past deviant episodes. Their peers dealt out support and

encouragement to do so and the students gained group status for their resistant talk. Implicitly, they were also giving one another some deserved recognition within the group for acting deviant. As Hawkins and Weis would have described, they became more listened to and gained more group authority and power for speaking and acting out more overtly to authority; certain social courtesies were granted to those who spoke out against the school than others. They were allowed to finish sentences, their jokes were laughed at, and they were chimed in afterwards where the two dissenting opinions were echoed with an awkward silence.

Rewarding members with time to talk and praising their resistance was a way in which my students were actively engaged in trying to decide how things got done in the class. They knew if they continued to lobby for emotional outbursts against the establishment, the majority would join in and I would have a more difficult time controlling the conversation. They wanted and pursued the talk about social issues, while I actively pursued an agenda of getting a completely different set of tasks accomplished.

Most importantly, in this section, however, was their ability to use classroom discourse to draw clear boundaries around their group members. In the excerpts provided in this recount of Brent's mishap in the tub, there were at least three different indications of students separating themselves from school. There were six direct criticisms of school as an institution (121, 129, 139, 140, 142, 175) four blatant

challenges to school as an authority (98, 188, 129, 167) and over 14 references to a "we-they" antagonism, implying the school as the villain. My students actively pursued the agenda of drawing clear boundaries around themselves that would allow them to operate separated from the school altogether. To better justify my classroom of alienation I shall use Newmann's categories describing alienation.

ALIENATION AFFECTED MY STUDENTS

To what extent are my students alienated? How does their engagement affect learning? I turned to Newmann's (1992) framework to examine the components of my students' engagement. My students' alienation from school can be better understood by considering the qualities that promote membership: clarity of purpose, fairness, success, and personal support and caring.

As a result of the unclarity of our purpose, we experienced misunderstandings. The general class format and scientific relationship to my students' lives were both foreign notions to them. At the beginning of the year, "What does science have to do with me?" was a general question. Science was not taught to emphasize the usefulness of scientific concepts in students' experiences. Some students informed me they were used to "book science" and their teachers exposed them to lectures and occasional labs. Surely their demands for answers in the beginning indicated how divided science was from their lives. This was also evidence of the failure to communicate "how" we were going to learn differently. I changed the rules of class participation and my expectations for them to treat one another.

Also, I asked them to tell me their individual beliefs so we could argue about them as a group. Brent's question, "What is this Yerrick, science or a self-help class?" was testament to the confusion we all felt early on.

Fairness was also a difficult area with which I did not have a significant problem. While I believed I was fair, I constantly struggled to keep things from erupting and to get students' compliance. As a result of this maintenance, there were seldom instances of discipline extending beyond a verbal warning and never beyond talking to students after class. Therefore, students did not question my fairness.

However, fairness was of utmost importance when regarding the assistant principal. Simply by their signing up for General Science, my students were automatically shifted to a certain placement level in school and were open for criticism. For example, during a class visit to discuss the school drug policy, my students received clear messages from the assistant principal; he made generalizations about my students' using drugs and their opinions about this activity. My students knew this class was the only class he confronted in this way, so they interpreted his message as "You are a drug using population and I am telling you what will happen when you are busted." Unfortunately, they presumed to be accused of wrong-doing without foundations of his accusations.

Their concern for fair treatment from the assistant principal dominated three days of their engagement; nothing was more important than getting to the bottom of this wrong-doing.

They took the adversary role to the school's efforts to socialize them. If my students had not directly asked me questions, the accusations that arose could have cost me my reputation and any possibility of trust. As a result of their skepticism and resistance, I arbitrated a conclusion to our disagreements.

Alienation toward school and science was certainly exacerbated by their repeated failure in science. As a group that spent the majority of the day together in the same lowered-tracked classes, they had very poor track records; their records revealed 33 attempted science semester hours. My students achieved a C or higher in only 11 hours and had a probable success rate of one hour out of three, not including classes they failed because of chronic attendance problems.

These past failures shadowed these students' efforts at new ventures; they were apprehensive of future failures and rather than face another opportunity for failure, they continued to choose alienating themselves from school. Since they were amid skeptics who constantly reminded them of their student culture and of their failed history, these students relied upon my reinforcements and reassurances for compliance.

Finally, my students' personal support and caring was difficult to speak of as a whole. Although I tried supporting each of them in class and inquiring about their personal struggles, my role was limited in helping them because of the diversity of their home situations. In my class, the students' family make-up consisted of two sets of foster parents, several

divorced parents, and parents wielding the promise of eviction in the event that their children encountered trouble in school or with the law. Therefore, personal, and outside support for the students' academic lives was limited. For example, while a few parents appeared for the parent participation/open house, only one parent attended the spring parent-teacher conferences.

DISCOURSE LEARNED IN THIS ENVIRONMENT

This breakdown of attempting to establish a new discourse gave me insights to larger problems. I realized my students' fractured lives were setting the stage for a difficult struggle of learning different ways to think about the world. They understood school in a different way than I did, and each confrontation was another piece of the puzzle for me to put together.

I concocted a plan of action in a series of gut level re negotiations to try to minimize the distance between us and get some recognizable work accomplished. I tried getting my students to use a discourse resembling the products of a set of different values. My students did not know "what" I was asking them to do or "how" this discourse was different from their past school experiences. As a result of not acting as they expected a "normal" teacher to act, my students reverted to ways that would better resemble how they would talk outside of school within a peer group. Such a discourse is laced with establishing pecking orders and getting things done in a way that contrasts greatly with the way they are asked to participate in school.

Our situation was complicated by collective notions of school. Even when individuals tried using the discourse I promoted, common practices tugged back on them. Students that took risks in front of their peers by complying and (in Gee's terms) "trying on" what I asked of them often paid a social price. Students used recognizable discourse patterns to communicate, "This is not how we get things done in here," and, "You are not one of us if you do as the teacher asks." I engaged in a battle of changing long-held and deeply-felt perceptions about school.

Our struggles consisted of trying to engage a loosely bound group of students compelled to attend a class that offered few rewards. In a larger context, students' inappropriate talk, rudeness to other students, disagreements about class expectations, and factors outside the immediate class context all paint a picture of marginal student membership. Yet, Newmann (1992) argued membership and authentic work, hand-in-hand, propagate engagement.

Generally, my students were not engaging in school despite my efforts to promote more authentic work for my students. Is perceived membership a precondition for engagement? If it is, then my students are destined for failure because they engage more in efforts to resist than to propagate membership.

The issues I encountered were not unique, but revealed the complexity of trying to engage students who were actively disengaging. The intensity of their resistance shocked me because they had grown beyond a passive tuning-out of teacher

directives. They developed into an antagonism, an enjoyable challenge placing students in the driver seat of their own failure. I once thought they were victims; I was only partly right.

My data reveals that blaming schools for sorting and tracking students is only a final aftermath of a dynamic in which the teachers and students play leading roles. Schools cannot be solely blamed for making arbitrarily judgments about students and at the same time, blaming the victim of tracking is far too easy. School staff and their students develop understood identities in relationships to one another, which often contrast and conflict. With such an environment to start with, no wonder teachers abandon change and revert to more comfortable roles. My negotiations were testaments of my own compromises in vision and attempts to build something only I could envision at the time.

However, my story has not finished; there was much more for me to learn about negotiating the social context and appropriating scientific discourse. This chapter has highlighted the agendas of the group to establish clear boundaries. The next unpacks the ways in which rules of the group about getting things done and dealing with status get re negotiated. This chapter serves multiple purposes, not the least of which is bringing more questions about what is really required to make changes in students' lives who have come to know school from a different perspective.

CHAPTER 4

OVERVIEW.....134

PERSISTENT CLASSROOM NORMS AND DISCOURSE.....134

STUDENT AGENDAS THROUGHOUT THESE NORMS AND DISCOURSE.....137

Gaining Status Using Distractions and Social Attacks..138

Less Overt Distractions Related to Social Agendas.....142

THE PROBLEM MY NOT EXERTING AUTHORITY.....145

USING STATUS AND AUTHORITY TO SET NORMS.....149

Renegotiating Agendas of Social Status and "What" is Accomplished.....151

Products of Renegotiating Discourse Norms and the Group "Work".....160

Other Products Revealing a Renegotiation of Norms.....168

Assuring Everyone's Right to Disagree.....170

Determining the Correctness of An Idea.....172

DISCUSSION.....176

We Made Progress.....176

Rules Did Not Stifle Students.....179

CHAPTER 4

Renegotiating Rules, Norms, and Authority

"You know we walk all over you in here Mr. Yerrick."
- Cindey

OVERVIEW

In chapter 4, I discuss the role of rules, norms, and authority in a science classroom. In arguing about the nature and place of authority, I explain why I considered changing my class rules and why the traditional set of rules and norms fell short of helping me achieve the goals I had for my students. I revisit the dilemmas associated with changing my alienated students' norms and discourses, and the difficulties I encountered trying to change the focus and products of this community's "work". Also, I elaborate on some of the problems associated with status among this community's members, describe the changes I endured in renegotiating status, and finally, point to the progresses and weaknesses of what occurred to make our expectations more coherent.

PERSISTENT CLASSROOM NORMS AND DISCOURSE

We traversed some difficult territory in trying to establish the conversation topic for class. I did not anticipate there would be difficulty in convincing my students that "science" would be the focus of our discussion. Some of the trouble they experienced dealt with eliminating a set patterns and my acting in ways they could not recognize. My

students tried interpreting my actions within their understanding of school. They, like most students, were accustom to recognizable teacher patterns that had understood meanings and routines. Consider the following interaction as a possible model for how they experienced science instruction.

> Teacher directs some questions toward the general student audience that the teacher deems important for them to know.
>
> Students compete among one another for the floor by raising their hands or using some other means of getting the teacher's attention.
>
> The nominated student then guesses what answer the teacher has in mind.
>
> The teacher, having already deemed what constitutes an appropriate response, evaluates the student's answer and moves on to a different question.
>
> If students do not raise their hands, they risk being considered uninterested or unknowing.

Many implicit, yet powerful, understood messages are communicated within this discourse. The teacher represents the one person who maintains the final authority over assessing the power of an explanation. The students are predisposed to pleasing the teacher and volunteering whenever the teacher asks for a response. The teacher also decides what topic is discussed, what questions are asked about the world, and what type of response students are allowed to provide. Clearly, this arrangement expresses the implicit message that the teacher sets student norms because the teacher has something students feel they should be receiving--answers or factual information.

Also, in this example, implicit rules for questioning convey the power inherent in knowing the answers. These "understood" rules of how class operates probably are not found posted anywhere in classrooms today. Instead, what are usually

found on walls are instructions such as, "Clean up after yourselves," "Take turns," and "Stay in your seat until the bell rings." Even though implicit rules may not be posted around the room as these may be, they are still understood by students and are equally influential.

However, this set of norms and discourse did not meet my needs for establishing the learning I wanted to promote. I was committed to breaking away from the teacher as the sole and final authority over correct answers. While traditional classroom discourse promoted the notion that science should result in factual and final claims about the world, I wanted to promote a more tentative approach to discovery. I noticed in my students' interview data that they made very factual claims about the world and were unable or unwilling to connect the claim to a larger set of evidence. In addition to interviews were daily instructional events in which students drove the discourse toward a more factual treatment of the world and claimed personal authority and expertise based upon their social status. In some events, they contentedly claimed, "This is how it is. I just know." At other times, they introduced past experiences and successes to determine acceptability of an explanation. Tasha once claimed, "I'm the one that got an A in math remember?" while Mona retorted, "Well my mom's the fireman and I should know." Traditional classroom discourse had allowed my students to stay at a level where they never challenged their beliefs about the world or constructively discussed world events they may have shared common interests or opinions. Traditional

discourse did little to promote arguments based upon evidence and allowed little latitude for a person of authority--teacher--to give final approval to any idea.

I also thought this traditional approach compelled students to make claims and seek answers that best fit what they guessed the teacher was thinking, and allowed them to focus only on what the teacher said and to pay little attention other students' opinions or disagreements. Also, if they are not called upon directly, this traditional approach isolated students from one another and from the teacher. I wanted students to disagree because this activity would help them practice using evidence to support a position they believed and practice weighing different or conflicting models or evidence with respect to their own beliefs. The traditional set-up did little to promote such interactions.

I was committed to withholding answers and requiring students to defend their ideas, but promoting this discourse left students uncertain about how to act. I was interested in establishing rules similar to the way a scientific community made decisions; everyone gathered data, raised questions, and demanded proof from individuals promoting ideas. We would, as a group, take votes to resolve conflicts. An idea was accepted if everyone agreed; therefore, group consensus became the authority over the "correctness" of and idea. As a result, I changed everyone's expected role of participation by restructuring interactions around some other authority besides myself and not telling students the "correct" answer.

STUDENT AGENDAS THROUGHOUT THESE NORMS AND DISCOURSE

Gaining Status Using Distractions and Social Attacks

While trying to change the learning environment, students realized some of their discourse norms did not meet their agendas. Students interested in pleasing the teacher could still raise their hands to be recognized, but they could not end their response by using factual claims about the world and be complimented for their answer. I continually probed their claims with, "Tell us why you think that," or "Marcus, what do you think about what Kristy said?"

On the other hand, students not interested in pleasing the teacher also experienced uncertainty about how to fulfill their agendas. While they could continue to alienate themselves by putting their heads down and tuning out altogether, they could no longer lay in wait for the teacher to make some mistake in subject matter because I was not the subject matter authority nor was I using right answers to keep students in line. Therefore, if students wanted to accomplish what they were able to accomplish in the past, they needed to discover other means to gain teacher recognition.

Some of the old school discourse patterns did not meet agendas that were important to them. However, my students were proficient with some discourse norms that enabled them to continue fulfilling their agendas. If my students wanted to expand their distance from me, they would offer a sarcastic comment at the precise time to draw the class off-task and, as a

result, they would gain status within their peer group and again place us at odds. Consider the following incident,

196	Tr	What would be evidence that digestion was a chemical change?
197	Micah	New substances form
198	Karlton	Changes color (all lobbying for recognition)
199	Kristy	Gas is produced. Yes!
200	Martin	(in sarcastic tone) Like a fart? (Class bursts out in laughter.)

My students typically opposed rather than conformed to my expectations in order to seek status from their peer group. Not only did they antagonize me, but they also ridiculed or "cut on" students who chose to do what the teacher asked of them. This traditional set-up allowed them to engage in adversarial activities that increased their group status for criticizing rules and those who obeyed them.

Students continued pursuing their agenda of establishing and fighting for group status by criticizing class members. Whether or not their criticism concerned students' ideas or personal problems, they were insulting and being rude to one another solely for the purposes of their own gain, and recognition. This type of discourse, the insulting one another, exacerbated the fear of participating for fear of being attacked or humiliated. This was extremely prevalent with females and quiet, withdrawn males. These people were easy targets, and the ways social leaders "cut on them" further convinced them that they did not want to make guesses or talk about their ideas. Popular students' pursuit of this agenda continually led to the breakdown of class activities. For example, consider Karlton's entrance into the class midway through a class discussion.

201	Tr	Hi Karlton. You're um...(looking for a seat for him)
202	Karlton	(interrupts teacher) I'm not. (Slams book on desk)
203	Tr	Why don't you come over with this group right over here.
204	Karlton	I don't feel like working in groups.
205		(Most students look up to the teacher for a response. Class jeering begins.)
206	Samuel	Bust him for that statement right there.
207	Erin	O-o-o-oh, but that's to-o-o-o bad.
208	Marcus	(Shakes his head) Karlton why do you always ...(volume tapers off)
209	Samuel	He had a ba-a-a-a-d day today.
210	Kristy	Po-o-o-o-o-o-r Karlton....
211	Cindey	Karlton, did you have a bad day?
212	Tasha	Anything that didn't happen in this class doesn't matter.
213	Erin	I don't want to work in groups either.
214	Tr	Karlton we could like ease you into one of these groups. You could be like real quite and contribute later on but for right now, you need to sit in, and this is the place you could do it.
215	Samuel	Ple-e-e-a-s-e.
216	Tr	You can be quiet for awhile but you need to sit in a group.
217	Kristy	Geez Samuel...You know you like him.

In this incident, students pursue two simultaneous agendas. First, they try to redirect how class work is accomplished. Students convey to Karlton that everyone is expected to sit in groups as the teacher instructed, or will accept the consequences. Samuel gives me approval to discipline Karlton for challenging my instructions because students are not supposed to counter teachers' authority (206), and Erin communicates she does not like group work either, but she follows teachers' directions (213,215).

However, the way they went about trying to steer how class work was accomplished disturbed me. Apparently, it was okay to criticize and attack individuals who choose not to follow the

lead of the group or the teacher. Their fellow students, in a cruel way, rejected their opinions as much as these individuals rejected group acceptance (207, 209-11). Karlton tried to separate himself from his peers for yet another time by implicitly sending them the message, "I don't want to work with them and I shouldn't have to (204)." In their own way, they understood what he meant and interpreted his abstinence as an insult. Kristy and others used this opportunity to mock Karlton for his emotional outburst (207, 210, 211, 215, 217).

This was a situation that required protecting students from themselves, and that was aggravated by agendas of alienation, status, and an agenda to do the social "work" of the class. In addition, this incident was enabled by a set of school rules and by expectations of rules that allowed students not to participate as a way of meeting these agendas. I stopped the criticism, defused the situation, and redirected the class toward the task at hand.

This was just one situation of many reminding me that the norms I wanted to promote were different from my students', which they were used to practicing. My ideal vision of scientists seeking to find answers together was not compatible with the ways my students competed and drove discourse in different directions. Perhaps, as a result of my trying to change the discourse rules and the uncertainty that this process introduced, my students inserted into the classroom antagonistic and hostile discourse norms that were more associated with peer

groups' interactions outside the class where democratic ideals of the class do not carry any weight.

Less Overt Distractions Related to Social Agendas

There were also other ways my students were rude to each other without directly engaging in hostile confrontations or ridiculing behaviors. At times, they ignored one another or interrupted discussions with side-talk. Some of them were offended and said the group was rude or they felt stupid when participating in discussions, but no one listened to what they said. While they continued to make an effort to contribute their ideas, some students busily pursued private conversations with others while ignoring the ongoing investigation pertaining to our scientific problem. This discourse pattern undermined several promising discussions.

One event that led to a turning point in renegotiating the class participation rules centered around one of Dimitri's questions of why a light bulb burns out if the glass is broken. Initially, some students also found this an interesting question and I suggested we pose some possible explanations and to see if we could support any of them with evidence. Dimitri suggested, "The air sticks to it and it changes into ash. That's all. That's what I think happens when the filament burns out."

I felt Dimitri had provided a wonderful explanation and, also, thought we could support this with evidence and use it to make sense of other chemical changes. I responded to Dimitri's invention with excitement and asked the class, "What do the rest of you think of that? Can we test Dimitri's idea?"

We spent the next few days running several tests. Dave set up vacuum pumps connected to bell jars with lights in them. Tasha and Marc videotaped bulbs burning out with and without air present. Samuel and Dawanda tested the filament at different voltages before and after it burned out. Though we could only sustain the bulb in the vacuum pump for approximately 10 seconds before it burned out, some students were convinced that air was responsible for changing the filament.

Karlton and Dave invented ways of testing this possibility too. We had candles inside the bell jar that went out when the vacuum pump was activated. Karlton even observed the smoke was pumped out and left through the exit valve. I burned magnesium and weighed the ash to see if there was a change in weight. Micah tried to weigh several burned filaments to observe any measurable difference. After the experiments were run, Karlton, Micah, and Dave agreed with Dimitri. We had not yet proven, at least not to the satisfaction of all the students, that Dimitri's model of air sticking to the filament adequately described what happened to the filament. One of my rules for deciding the veracity of an idea required that everyone was convinced in order for us to proceed to another question. So, we still had to convince the others.

I had not convinced them of the veracity of Dimitri's idea even though I figured Dimitri's idea was basically adequate. We lacked evidence that students' needed in order to take Dimitri seriously and the respect for one another to listen to each other's ideas. When the class reconvened to discuss all the

different groups' work, very few people listened to the other students. They did not seriously consider Dimitri's or anyone's ideas about the filament, so the problem became as much as one of sustaining meaningful conversations as it was finding evidence to support or refute Dimitri's model.

The dilemma of proving a scientific idea was exacerbated by the lack of respect they held for one another and myself. Again, class grounded to a halt while some students busily conversed about topics unrelated to our inquiry about chemical change. Even though there was activity and evidence to use in conversations to support the best explanations, most students did not find it as interesting as I did. What was interesting and compelling to some of us--Dimitri, Tasha, Dave, Micah, and I--seemed incidental and unimportant to other students--Cindey, Erin, Kristy, and Samuel--who were engaged in conversations about relationships and after school activities.

They were still, at least in private, trying to forward their own agenda of social matters and driving it to be the work of the group. Although my students were not attacking the students trying to contribute to the class discussions, they were doing something equally disruptive; some interpreted these private conversations as rude and reason enough not to continue talking. Despite the fact we experienced many confrontations about what the discussion topic ought to be, the class norms still had not been renegotiated to the point where the "work" I perceived should be done was ever accomplished. So, what we tried to accomplish still was not consistent with everyone and

those who did not participate were disruptive to those who were. While I tried to renegotiate the substance of our discussions, most students considered class social work was paramount. They were not interested in listening to what other class members had to say relative to the light bulb or constructing arguments about the natural world.

THE PROBLEM: MY NOT EXERTING AUTHORITY

This side-talk and basically the class "work" needed renegotiation, not only because I felt too much effort was wasted on redirecting class discussion, but also because students told me people were rude and they did not want to contribute to group discussions. Also, these students believed groups would not hold their ideas as important enough to consider and this made them angry and embarrassed.

My students interpreted the problem somewhat differently than I. Much of the feedback I received about this incident and related events focused on my actions supporting much of the distractions. My students interpreted the problem as me, the teacher, not taking a more authoritative role in the class. After the discussion of Dimitri's idea broke down, Micah and Samuel came to me after class and told me that if I expected students to listen to one another, I was going to have to get tougher. "Kick 'em out of the class, Mr. Yerrick!" Micah exclaimed. Samuel pointed out that his other teachers threw some of the same students out of their classes and suggested this was the answer to the problem.

We had a one day school break when my class did not meet and I took the opportunity to ask other students in the class what they thought the problem was and what they thought should be done. Their responses echoed Micah and Samuel's interpretation that students needed to be controlled.

Karlton I don't like to participate in class. I think people are just plain rude in this class and I don't like to work in groups in this class.

Erin The talking gets out of hand. I know we shouldn't do it.

Cindey You know we walk all over you in here Mr. Yerrick...,but I don't want to tell you what to do 'cause I'm one of the ones doin' the talkin'."

I had students write about their ideas, experiences, and feelings about the class. Then I read some of their journal entries. Micah's entry was especially poignant:

> Well, it just happened again. I am in science class and I was trying to express one of my ideas when some ignorant buffoon cut me off. They just don't seem to care. When someone does this I just feel like, "Fine! If this person don't want to hear what I have to say then the hell with them. When this happens, I usually don't say my idea, then I might forget it. I do this because I know that they have cut me off and I don't want to express my idea to them.
>
> Although I may get cut off, sometimes I don't get mad. It don't bother me if another person's idea is about science. I only get upset when the idea is something other than science.
>
> When I said (to you, Mr. Yerrick) that it was not fair that I am in a class with these people, (I meant) that when I am in science class I try to come to learn. I don't like it when I get interrupted by someone talking about things that can be talked about outside of science class.
>
> Trying to participate in class is frustrating sometimes because of people's attitude. When some people are trying to solve a problem, others are not tuned in. When this happens it does not benefit me in (the same) way that if there were students that was helping our group etc. It could help me in a way in which I could get more ideas with their input. At a faster rate.
>
> Some of my biggest frustrations in class are trying to do work when others are just playing around. Mr. Yerrick I think to have a better class you should be more strict with

> students. When someone is not paying attention, the student should get some punishment. I think that if you were more strict that some people could get a lot more from your class. I believe you have a good class. The only problem is when you get students that don't care. When you do get students like this you should get them in order or get rid of them. (Micah's Journal entry in reference to 10-5-93)

Micah's journal entry and other students' comments revealed that they interpreted the problem as me being too lax and not taking enough control over students' behaviors. Students told me that it was my responsibility to take action on the deteriorating conversations in class. I was not helping students to gain more powerful thinking by letting them say what they felt or determine their own rules for interaction. Though I was uncomfortable simply telling them to "Be quiet or get out," as Micah and Samuel suggested, it was counter to my goal of including all my students, but so was allowing them to dominate the class with inappropriate behavior. Still, I was unclear how to get students involved if I did not dominate them.

My pedagogical choices and discourses I used to engage my students in subject matter led to another set of misinterpretations. Frequently, I used questions such as Dimitri's as ways to approach the subject matter. I was interested in questions and issues students raised and used their thoughts to direct the inquiry and evaluate the answers proposed with their evidence. In doing so, this allowed them to determine the study topics. My students interpreted my reluctance to give answers and perhaps other unrecognizable discourse patterns I used as signs that I was not interested in exerting any control over them at all. I had given up not only

my subject matter authority, but most other authority as well. By giving up this authority, some students interpreted this as an opportunity to discuss whatever they wanted to and used their freedom to choose not to engage in the class discussions at all. As a result, I gave up more than the authority over the correctness of ideas; I lost control over the class as a whole.

The agendas students pursued set an unproductive tone for the work I wanted to accomplish. Social status was important to them and they were not averse to ridiculing their peers, abstaining from group work, and sometimes intentionally derailing discussions to attain their status. Clearly, while trying to renegotiate some other ways for us to interact as a group, I needed to use the authority inherent in my teaching role to stop certain interactions. However, this left me with a set of complex questions of how to go about making such changes. What were confusing and conflicting interpretations turned out later in my analysis to be a compelling set of questions about their agendas: What could I do about my students' agendas that still came in the way? If my students came to understand classroom interactions in the context of answers being used to set the tone of classroom discourse, how could I make my intentions clear about what "work" I thought the class should accomplish? If I was not going to act like a subject matter authority, then how could I act like an authority in other ways? Why were they willing to push the limits my authority?

USING STATUS AND AUTHORITY TO SET NORMS

Extremely frustrated, I decided to take a more active role in shaping their interactions and changing class. The day after asking students their opinions about the class, I clarified what I now expected. I expressed that the changes were for the purpose of hearing students' ideas; therefore, students were not to interrupt discussions or be rude to the person talking. In addition, I spelled out a system of reprimands with clear signals for the level of consequences.

25	Tr	I've been talking to some people in the class and they feel...ahhh...some of the people in the class...I know this isn't quite the majority, but some of the people in the class feel that people aren't allowed to um...state their opinions, and when they do they get kind of ripped on. and when some people are talking, other people don't listen.
26	Dave	This class?
27	Tr	In this class.
28	Dave	Never. Come on.
29	Cindey	That's the truth.
30	Kristy	What'd you say?
31	Tr	That when people are talking, people don't listen. And that they're very disrespectful. And Erin, Erin, this is what I'm talking about. That when one person talks, that everyone else needs to listen to them. And I've been going back through some videotapes and reviewing what people are talking about and I think they are very right. I think that they're right on target when they say that people in this class are very rude. And that they're saying, "When I talk, I feel really stupid cause no one else ever listens." ...We just plain don't listen to each other. So I'm going to take some steps. And I'm taking these steps because I think it's the right thing to do and also because I've also some people that have said, "Mr. Yerrick I think this is what you should do." So. What's going to happen is the following. In the future, in the future, what's going to happen is the first time, I'll give you a warning. I'll say that's one. You just interrupted Micah or you just interrupted Dawanda. That's once. But after the

		second time, you'll go in there [teacher's office] for 10 minutes, by yourself. And after the 10 minutes you come out and after the third time during that hour, you go to the office.
32	Tasha	Pretty cool...(inaudible)
33	Samuel	Good job Mr. Yerrick.
34	Tr	And you're welcome to come back the next day, but for that hour you're gone. Maybe you've got some problems you need to deal with, but our class is going to (inaudible).
35	Dave	Good call Mr. Yerrick.
36	Tr	Good call?
37	Samuel	Good call, bud.

Immediately following my explication of the system I was going to use for reprimands, students began negotiating what they interpreted as fair. Somehow my statement of rules and consequences had signaled to some of them that this was an appropriate time to attempt to influence the set of expectations I had set out for the class.

37	Samuel	Good call, bud.
38	Tr	(imitating Samuel) Good call, bud. All right...Um that's how it's going to be. And each time a person like the second time they've got to go in the room, each time that happens I'm going to contact their parents...So, if their parents get five calls during the week then...
39		(much commotion)
40	Erin	Oh no.
41	Cindey	O-o-o-o-h hooo
42	Kristy	Just make sure to call on certain days when ma' answers.
43	Tr	Well, that's what I feel I need to do.
44	Kristy	Don't call my dad.
45	Tr	This is also....It's something that happened...um...It's something that came up during parent teacher conferences as well and I know that your parents are interested in being a part of what's going on in class.
46	Dimitri	Call Dave's house.
47	Kristy	Yeah call Dave's mom.
48	Tr	I talked, I talked with both of them (Dave's parents) and Dave is by far not the one that interrupts the most.

Conversation broke out about calling parents, and other disciplinary actions of administrators and past teachers. Of

course with my students there was talk about how to beat the new system. Students tried to influence how and when I called, or tried to divert attention away from themselves. During the commotion, Brent told me he would hang-up if I called and I would never know it was his house. Erin suggested I tell everyone first when to expect a call at their house. Finally, all students present nodded and gave other verbal and nonverbal signals that they agreed to live with this suggestion.

Even though there was some resistance, I felt pleased I responded to a difficult situation that held promise for my original instructional outcomes. I knew this would be more difficult than simply stating my expectations. There had been many breakdowns and renegotiations, even about the conversation topic, that took work to sustain any change. In principle they all agreed. However, I was shocked with the supportive response I received, not only from Samuel and Micah, but from others as well. Dave jumped right in gave me a thumbs up and said, "Good call." I needed this support to maintain the confidence to reprimand their rude behavior. I knew there would be real resistance to my efforts to control the class. While, they gave me the authority, they had not yet felt what it was like to be ruled by me. I was about to be surprised at what problems I would encounter.

Renegotiating Agendas of Social Status and "What" is Accomplished

In this next section I describe a series of events that revealed to me that I had not considered all the factors influencing my students' perception of the class. I present how

my students and I came to some meeting of the minds in trying to establish what was appropriate and what products would result from our discussions. Finally, I describe how learning new roles in new power structures requires learning on the part of the teacher as well as the students.

The next day we worked in small groups to establish our beliefs about chemical change and then argued them with the rest of the class. I knew large group discussions broke down in the past. So, I made a point to remind them of the prior day's discussion about the new system, that this was the time when the rules of behavior and attention were important, what disciplinary steps I would follow, and reiterated my expectations.

Less than a minute had elapsed when the first major controversy emerged. Samuel's partner, Erin, was the first to volunteer their group's discussions concerning the baking soda and vinegar reaction. Once Erin finished telling that the change was chemical because new substances bubbling was observed, I asked the groups if others agreed with Erin's explanation and if they had any other reasons to support their answer. Kristy, who is a mortal enemy with Samuel, began describing why her group agreed with Erin. As she started, Samuel decided he, for one, was not interested in what Kristy had to say.

49	Tr	Does anyone have a reason besides the ones that Erin gave for agreeing with this (chemical change)?
50	Kristy	Yeah. Um, we put because the baking soda dissolves and can't be brought back. Like after you put baking soda and vinegar together, baking

		soda dissolves in the vinegar and it's...
51	Samuel	(yawns loudly) Oooh-Ah-Oooh-Ah-Oooh-Ah-Oooh-Ah-A-h-h-u-u-h-h!
52	Kristy	(Stops talking)
53	Tr	Samuel....That's a warning.
54	Samuel	I was yawning Mr. Yerrick!
55	Tr	That was inappropriate.
56	Dave	(laughs)
57	Tr	Kristy you're still talking.
58	Samuel	(Under his breath) Sheezus Christ.
59	Kristy	I was saying that baking soda is being dissolves and foaming occurs.
60	Tr	Okay gases appear and foaming.
61	Karlton	(talking to his neighbor)
62	Tr	Karlton...That's one. That's a warning. Okay. Number...
63	Karlton	(inaudible)
64	Tr	(Tr hesitates, look at Karlton, holds up hand and shakes head) Okay number two. Any group want to answer number two. Erin, your group already went, so....
65		...I'm going to give another group an opportunity.
66	Samuel	I'm NEVER answering ya' (puts his head down).

At the time, I was fairly certain Samuel's actions were not inadvertent, but rather a statement of how he felt about Kristy. Samuel looked at his partner, rolled his eyes up into his head as Kristy began to talk, and proceeded to exaggerate his yawn. Samuel and Kristy's struggles for status had a profound history, and because of this history I knew I made the correct call. On one occasion I had to stand between them and demand they quit being so hostile toward one another. They informed me of their continued fighting since elementary school and how they resorted to using sticks to resolve their fights. It was timely that I intervened. I believed that I had Samuel's blessing (33,37), but his response suggested I was not going to greatly influence how he treated Kristy (54, 58, 66).

This incident should not have been a big deal; it was only a warning. Samuel's' hostile response revealed it was a threat

to his class social status to be reprimanded in front of his peers. Apparently, he had given me authority to confront others who interrupted his learning (33,37), but he had not given me a blanket permission to confront him for anything that he might do (58).

Samuel was angry with me using authority on him and he publicly vowed to undermine my efforts by not participating (66). His withdrawal following our confrontation was yet another attempt to discredit his school critics and reestablishing clear boundaries between himself and school. Because of their history of disrespect for one another and Samuel's efforts to distance himself from me (66), I could only limit their attacks on one another. I could not make Samuel care about what Kristy had to say.

Class went on and the confrontation subsided for a short time before Samuel quickly revealed he was interested in making sure everyone met with the same justice. As another person yawned in the class, Samuel quickly raised his head and identify who it was. Samuel inserted some verbal and nonverbal cues that he wanted to influence my interpretations of students' behaviors (79).

67	Tr	Micah you're helping her out but tell everybody what you're saying.
68	Micah	Well, I think condensing air and it evaporates.
69	Tr	When you say condense what is it you're talking about?
70	Micah	Water vapor starting to...
71	Erin	(Bursts out laughing)
72	Tr	(Points to Erin) Erin,...That's one [warning].
73	Micah	I think that has something to do with it.
74	Tr	Okay. I heard three different,...if I'm understanding you right, you're citing three different forms of water one is solid, one is

		the liquid that you find on the grass, and the other is the gas in the air? You're citing those three? You're saying something about condensation is the change and evaporation is the change in those?
75	Micah	Like...Condensation is when ah water is like on a surface and when it evaporates is when it evaporates into the air and condensation is when it goes from the air onto the surface.
76	Tr	So, if I'm understanding you right, you're saying that those three...(glances over to Kristy and Cindey whispering)
77	Tr	(Hesitates) Kristy.
78	Kristy	Sorry.
79	Samuel	Well? (looking at me and pointing to Kristy)
80	Tr	Do you have a problem Samuel?
81	Samuel	(waves his hand at me as if to dismiss my actions) No Mr. Yerrick. No problem...No problem at all. (puts his head in his hands).
82	Erin	(barely able to talk to me through her giggling) It has nothing to do with...(stops laughing as I continue to look at her) I'm sorry.

I am not sure why I did not give Kristy a warning. I think it had something to do with her and Cindey actually talking to one another about how to solve the problem. Maybe I was just treating girls differently than boys. I *am* sure I did not want Samuel to feel he was open to pass judgment on every warning I gave. So, basically I dared him to challenge my authority in front of the class. "Do you have problem, Samuel?" (80) I asked with a deadly seriousness in my tone. Samuel knew what that tone meant. He heard it many times before, but never from me. I was asking Samuel if he had a problem with me being the sole authority and he resigned from the confrontation in not so gracious of a way, "No, Mr. Yerrick. No problem at all" (81). Even Erin sensed my seriousness as her laughter crumbled under the weight of my stare (82).

Samuel again put his head down in protest, as I attempted to continue the conversation. I remember feeling a bit shaken.

As I reviewed this data over and again, the high level of emotions always returned to me. All I had wanted was for people to listen to others' ideas and critically evaluate them if they accounted for all the evidence. I did not want to be forced to deal with power struggles in the class. I was not comfortable with exerting large amounts of power and I apparently regressed to old habits of simply stopping conversation to ask others to be quiet (77). Instead of maintaining a consistent tough disciplinarian front, I slipped back into familiar patterns of stopping and addressing the student directly instead of following my new system of discipline. I was wrong, but I did not want to communicate to students that they were able to make the calls about appropriate behavior. I was definitely caught off guard.

Samuel's persistence in trying to influence how students were allowed to participate was evidence of his agenda to reestablish his status by claiming he had been treated unfairly. Only minutes later Samuel corrected me again.

83	Tr	Cindey did you hear what Erin said? You need to be in this. You need to be in this. This is part of listening to other people. You asked a question and we're trying to answer it. You need to be paying attention to...
84	Cindey	Sorry.
85	Tr	What other people are saying. Erin...
86	Cindey	Erin what did you say?
87	Samuel	(to the teacher) Warning!
88	Tr	(Nodding to Samuel) Yeah.

I was compelled to satisfy Samuel's efforts to continue discipline in the same way he had been confronted. Samuel was right. He was absolutely consistent with my sense of when the conversation had diverted and when my expectations were

violated. I had responded differently to another girl he regularly competed with for status within this group (77). He demanded justice (79, 87) and the social redemption of being correct in front of the class. In attempting to right a past wrong, I spoke directly to Samuel and agreed with him that his perceptions were correct. "Yeah," I agreed as I weakly used power to rebuke the behaviors of his peers. Cindey did not acknowledge I had warned her. Again, Samuel had caught me reverting to the old behavior of publicly scolding individuals instead of taking direct action (83, 85). He knew he was right because of our recent confrontations that made my expectations clear to him. Also, Samuel was not afraid to tell me publicly I needed to meet my own promises of policing behavior (86).

I was embarrassed that I had been confronted again with my own inconsistency stepping into this new role of disciplinarian. However, I knew Samuel's comments could be used for the good of the class. I was learning how to be consistent, fair, and appreciate students' relative social status, but I was also learning how to be corrected by students in the midst of exerting power.

With all these concerns hitting me simultaneously, I was not astute to Cindey's interpretation of the event. Cindey had missed her formal warning as Samuel had been the initiator and not I (87). I had, in fact, looked directly at Samuel when I agreed with his interpretation of the norms of the class (88). I blissfully went on with the discussion and discovered Cindey had not been affected at all by the last warning. I wanted her

to consider others' ideas as important, but she was pursuing another instance of side-talk for which she had just been warned.

90	Karlton	If you boil water and you hold something' over it and it condenses on it. Like, ah Like you put a pan on a lid when you're cookin' stuff. The water condenses on the lid and you take the lid off and the stuff all runs off. It's the same thing
91	Tr	Cindey, would you go in that room and spend some time by yourself?
92	Cindey	I didn't even get a warning.
93	Kristy	Me?
94	Tr	The last time I spoke to you it was.
95	Kristy	Me?
96	Tr	Because I said you need to listen and you weren't listening.
97	Kristy	I didn't do it.
98	Cindey	I *was* listening!
99	Tr	You weren't.
100	Cindey	Yes I was. You didn't even give me a warning last time you talked to me.
101	Tr	Consider yourself...
102	Cindey	You gave everyone else a warning...
103	Tr	Consider yourself warned now.
104	Cindey	Okay.

I had missed communicating Cindey's warning. In her mind I had jumped right to the stage of calling her parents (92). Cindey began by defending herself and arguing she was listening to others. I pressed her and exerted my authority claiming the right to judge her actions. Realizing she could not argue she had been listening (she had no idea what Erin or Karlton had said) she changed her defense by pointing to my inconsistency and my weak warning (98, 100). I was unclear the last time and made sure there were no misunderstandings this time. As I warned her, evidently Cindey was less in disagreement with whether she was being rude and more concerned with having to go in the room, which would result in me calling her parents (104).

Cindey was a great offender regarding initiating side-talk and social conversations. Her agenda was similar to others as she sought to take care of much social business, but Cindy had a serious interest in not allowing her parents to find out about any trouble in school Her parents had threatened to greatly influence her social life by taking away her privileges (car, curfew, etc.). As a result, I had struck a chord of real personal significance with Cindey. While she may not have been interested in being polite because it was the socially correct thing to do, she sure was interested in staying out of trouble with her parents (92, 100, 102, 104). Clearly, Cindey had used class rules to her advantage; she successfully avoided parental involvement by renegotiating how I warn students and conduct class.

In each event, students' prior agendas help readers understand struggles I encountered. While Samuel drove to alienate himself further after competing for social status with Kristy, Cindey sought to maintain her social status by negotiating with me ways to better signal her reprimands. Throughout each renegotiation, there evolved meanings of "what" we would accomplish in the class. We worked towards some agreement of what work would get done by individuals, the collective, and myself. While they needed to learn roles of treating one another more cordially, I had to learn how to judiciously reprimand their behavior without controlling the outcome of their substantive arguments.

So far, I have described how my students and I ground through a painful process to work out a set of mutually accepted expectations and discourse norms. Even though I had made some well thought out decisions about their participation, I failed to consider that their understanding of school and authority would jade their interpretations of my openness to their interests, input, and influence in setting the tone of the class.

Products of Renegotiating Discourse Norms and the Group "Work"

Shortly after the initial heated confrontations, the discussion began to look different than others in the past. Some norms such as posing tentative warrants I had promoted and the "work" such as evaluating and weighing evidence against these warrants I had intended to accomplish began to be sustained parts of conversation with little interruption. My class had seldom listened to their ideas, but now they were learning to use a new way of group speaking that before had been nearly impossible to obtain with all the insults and interruptions. Though this was only the first day of these new rules, some products immediately changed. I now present how the products shifted and my work became a part of their work.

Micah's group had concluded that clouds forming in the sky were physical changes. Some reasons they offered hinged around the notion that clouds could change into different forms by adding or removing heat. As I paraphrased their responses, I sought other groups' feedback.

115	Tr	This group (Micah's) is assured, has assured each other that it's physical and Cindey thinks it's chemical. I want groups from outside to tell us what they think. What they've heard Cindey say and what they've heard Karlton say.
116	Dimitri	I think it's chemical.
117	Tr	You think it's chemical. Tell us why.
118	Dimitri	'Cause it's just like in a steam room...clouds. That's why it has to be hot or cold.
119	Tr	Okay, you want to know if it has to be hot or cold and that makes a difference?
120	Dimitri	Uh huh.
121	Tr	Tell us why.
122	Dimitri	Because you know how the steam room gets....You know how you turn the shower on? And that looks like little water droplets float around or whatever that's what makes the steam. Little tiny ones.
123	Tr	Why is that chemical? You're saying it's chemical and why does that help you to decide that it's chemical?
124	Dimitri	Because it turns from water into a gas. Wouldn't it? That's not a gas I guess, but....Is that what a cloud is like? Like those little droplets like?
125	Tasha	Um Hmm. It's the water.
126	Karlton	It's still water. It's just hotter than...
127	Tr	So why is it that you think it's chemical? Tell us why you think that forming a cloud is a chemical change.
128	Dimitri	(looking up at the ceiling) I don't...I just....So like if a cold wind came then all that water, those clouds would shrink up and rain?
129	Tr	(To Micah) What do you think?
130	Micah	Yeah.
131	Karlton	(To Tr) I just think that...
132	Tr	(Pointing to Dimitri) He asked a question.
133	Micah	Yeah.
134	Samuel	No.
135	Tr	He asked a question. He asked the question that if a cold thing came through all that misty stuff, would it come down as rain?
136	Samuel	No, it wouldn't.
137	Micah	Yeah, because like if you, if you have in your bathroom, a hot tub or something like that and you had a sky light in the window or something, all the cold air from the skylight would come in and it would rain in your bathroom.
138	Dimitri	No-o-o-o-o! (Get's up and walks to the waste basket.)
139	Samuel	No-o-o-o-o.

140 Micah It would! Because the water would glob up and all fall down because it got cold up there.

I also had students talk to one another about their ideas instead of simply talking to me. Most class discussion had been directed through me for fear of retribution from peers. While students made public statements about their independent thoughts, there was little attempt by others to consider the validity of any one viewpoint. Students were satisfied with some sort of soliloquy statements such as, "I just think that..." and "I think..." (116, 131). I forced them to evaluate one another's ideas by instructing Karlton and Micah to respond to Dimitri's question. I interrupted their response and demanded, "He asked a question." As a result, I changed the focus and substance of the class discourse class by having students talk to one another about their ideas.

However, this discussion was not driven entirely by students' interests in ideas. Clearly, I needed to be an active part of student-to-student interactions. Dimitri had thought out loud and made a claim about cloud formation, "I think it's chemical." I responded to his claim with four challenging "why" questions (117, 121, 123, 127 , two invitations for alternative viewpoints (115, 129), and one directive to Micah and Karlton demanding they answer Dimitri's question (132, 135). Though the discussion was centered around students' ideas, this process was only partly spontaneous.

By using my teacher authority, I was able to make Dimitri verbally reason through a position, thus modeling a way to construct a set of backing for a warrant. I also forced

students to agree or disagree with him, forcing them to take a more solid position in front of their peers that could be defended or refuted. In the past, students had been hesitant to do so. I had used my position to exaggerate the differences among students' explanations and made them address one another. Dimitri felt my pushing as I asked, "So why is it that you think..." (123, 127). He momentarily retreated, "I don't....I just....So if....?" (128). I pushed students into factions and made them use evidence to support their ideas.

As a result, several students became involved more often and in different ways. This involvement was evident in many forms. Initially, students staked positions I had facilitated. Students made tentative claims about real world events under consideration (115, 116, 131). Students made an argument around Dimitri's claim about drops somehow combining to form steam gas. I invited students to rebut this explanation, "So if..." (128). Micah and Karlton invented thought experiments to defend their ideas, "If this...then it would..." (137). There was even an emotional component to their arguments revealing their level of involvement. Somehow, Micah and Karlton's thought experiment was beyond belief (138-9). Dimitri was so disturbed by what his fellow students had claimed about his condensation idea that he stood up from his seat, turned, and walked away from Micah. Micah's idea challenged Samuel and Dimitri's deeply rooted notions about rain in the bathroom; this was too unbelievable. Dimitri scoffed at them as he walked away. Samuel also found their explanation difficult to believe. He was drawn into the

conversation to think about the public vow he had made not to participate.

Our class had seldom listened to their ideas and now we were practicing a new way of speaking and accomplishing a different set of "work" that had nearly been impossible to attain with all the insults and interruptions. They were engaging collectively in class activities that demonstrated more coherence with my agendas and the ideas I wanted to discuss. As the argument advanced, apparently, they were about to reach a consensus. Dimitri changed his position and nearly everyone had given evidence that cloud formation was a physical change. Everyone but Cindey.

141	Tr	Karlton, you were talking about cooking and water running. Tell us again
142	Karlton	Like you stick a pan a water on the stove an you hold a lid over it about this far above it. You can see the steam condensing on the lid. And you hold it like this and it all runs off. It's still water even when it's between the boiling water and the lid.
143	Dimitri	It's gas. It turns gas.
144	Erin	It just changes form.
145	Micah	It hits the cold...
146	Tr	So they're talking about the same thing.
147	Karlton	It's water It's just in a gas form.
148	Samuel	Yeah.
149	Erin	(raising her hand) I have something'...
150	Tr	Okay Dimitri, do you think it's chemical or physical and why?
151	Dimitri	I think it's just physical not chemical. I meant physical,
152	Tr	Okay. So Erin, you and Karlton and Tasha have helped Dimitri to sort through, he said, "I think it's physical now," but we go back to Cindey because Cindey's original thing was if it's different clouds then its a chemical change. If the same clouds don't come back.
152	Tr	So Cindey, what do you think about what you've heard from these four people?
153	Cindey	I still think it's chemical.

154		(Class get's restless. Marcus pounds his desk; Karlton thrusts up his hand; Micah shakes his head)
155	Karlton	If its a chemical change...
156	Dimitri	They're two substances...!
157	Tr	Why?
158	Dimitri	...to make it chemical.
159	Tr	Tell us why.
160	Erin	You're so stubborn!
161	Tr	Tell us why. That's important.
162	Samuel	Why?
163	Cindey	(changing her mind) Okay. I think it's physical.
164	Tr	No, Tell us why. Tell us why you think...
165	Cindey	I told you why I think its' chemical.
166	Tasha	Well tell us!
167	Kristy	You mean physical.
168	Cindey	Yeah, I mean physical. Yeah physical.
169	Tasha	(Laughs) Do you think its chemical or physical?
170	Samuel	Do you think...(inaudible)
171	Tr	Yeah, tell us what you think.
172	Cindey	It's physical because it changes.
173	Tasha	How does it change?
174	Cindey	Did you guys not just spend 20 minutes telling us how...
175	Tasha	(defensive) I was just asking.
176	Tr	Yeah, but we want to know what you believe about this. It's important to know what you think.
177	Cindey	I don't know. All I did was give my little perspective on it. It wasn't my idea in the first place all I did was to...
178	Brent	You shouldn't have said anything and you wouldn't be in this predicament.
179	Cindey	Well, I don't want to be in it anymore.
180	Tr	Okay, Cindey you're agreeing that it's physical? Is that what your saying?
181	Cindey	Yes.
182	Tr	And do you have a reason that you agree that it's physical?
183	Cindey	'Cause everybody else does.
184	Tr	Okay, that's you reason.
185	Cindey	(to Kristy) What do we have written down?
186	Kristy	(reading the group's paper) Good answer! Good answer!

I had gotten some students to think critically about one another's ideas as well as structuring the activity so they could use more powerful ways of speaking and reasoning. I was no longer solely responsible to challenge explanations. As I observed students using questions such as, "Why?" (155, 162,

166, 169, 170, 173), I had moved at least some students into the role of questioner and evaluator. My students' "work" had been renegotiated to collectively pursuing explanations and building knowledge.

But, factors including social status influenced this renegotiation. One interpretation of Cindey's response, which is supported by her quickly changing positions after hearing her peers' disapproval (163), is that she changed her mind based upon the social popularity of her position and not the strength of evidence in her favor. She did not provide the class with much substantive reasoning for accepting the explanation that cloud formation was a physical change, and she had allowed others to progress without deterrence. Cindey's resistance to defending her position in front of the class told me she was not interested in publicly arguing about the world using evidence, but rather maintaining her social status by conforming to group explanation. Cindey knew she could achieve this by agreeing to an answer; she wanted to be out of the focus of controversy more than working through examining her position. Therefore, she seceded in an attempt to get the class to proceed with other explanations (177, 179, 183).

Cindey had found a way to compromise my set of rules by promoting consensus for reasons other than supporting evidence. This was a continuation of earlier attempts to renegotiate how to discuss about clouds. While students were engaged in arguing about what evidence supported what position, Cindey and Kristy tried influencing the process by compromising opposing

explanations. They did not see the point in asking students to disagree.

105	Kristy	Are we still on clouds?
106	Tr	Yeah we are. We have a disagreement. We have a disagreement here.
107	Cindey	Man, we stay on subjects forever in this class.
108	Kristy	I know; I hate that!
109	Tr	I know, but we have a disagreement here and that one of rules, one of the rules about this class...please sit down Dimitri, one of the rules of this class is that we don't move on if there's disagreement. We have to resolve it as a community.
110	Cindey	Then everybody just agree on something.
111	Samuel	This could take forever.
112	Tr	Yes it could. Yes it could.
113	Karlton	So, you're telling me that we could talk about clouds...(inaudible)
114	Kristy	Clouds are physical and chemical in both ways.

Cindey and Kristy continued to insert more traditional norms. Cindey suggested the class choose something to agree with (107, 110) so they could move on; Kristy tried helping everyone be correct (105, 108, 114). Both attempted to bring the argument to a end without dealing with the differences of the two opposing viewpoints. I had structured the discourse around evidence, but had not thought students would renegotiate what was accomplished circumvent my intentions through their participation. I was struggling against an interpretation of class rules and expectations, which at least two students wanted to forward for other agendas.

Fortunately, other students did not buy into their efforts to depart from this argument about how clouds were formed. As a group, the members told Cindey she had not followed acceptable renegotiating norms. Several communicated that it was not acceptable to concede that the reason she agreed was because she

did not want to stand outside the general opinions of the class, instead of agreeing evidence had proven her point wrong (154, 156, 158 ,160, 162, 166, 169, 173). Apparently, they not only have adopted certain ways of speaking to one another that I had promoted, but they also excluded some individuals based upon their agreement to follow accepted ways of speaking. Brent even suggested she should not contribute if she did not want to play by the rules (176). Interestingly, these were rules based upon my patterned discourse they had helped to renegotiate, but I had instigated. Cindey had a choice to maintain her contact with the work of the group, to maintain her status, or to bow out and establish status in other ways such as resisting teacher-propagated norms. I was left to judge whether I wanted to help her understand and practice renegotiating norms, to draw her in deeper, remaining true to our goal of group consensus, or move on with the class discussion. By agreeing for the wrong reasons, Cindey made it possible to reach consensus, but in essence, we still left her behind.

Other Products Revealing a Renegotiation of Norms

There were several indications that the class work had been renegotiated and that the products were more representative to what I wanted from them. The shifts in the class products took two forms. First, the ways in which the class ideas took the forefront, instead of issues related to more social matters. Students volunteered their ideas for discussion, took sides, listened to one another's claims, offered support based upon evidence for their ideas, and brought personal experience and

evidence to the focus of discussion to support warrants they forwarded.

Second, there was also a social component of steering and monitoring "work" that I observed where they took on some of the roles of promoting this discourse. What I had interpreted as total breakdowns resulting from my own weakness had, to some degree, changed all of our problems to direct the discussions. Students took on my role of promoting my discourse as they influenced when and how I gave warnings, adopted some of my promoting-talk techniques including questions such as "why?" and "tell us what you think," and also excluded some students from participating if they did not follow the new rules.

With their help, our "work" of constructing arguments was able to proceed, despite some interruptions and Cindey and Kristy's efforts to derail arguments. This assistance combined with the emotional component that was tied to a set of evidence and interpretations once associated with social issues supports the claim that the agendas of status and work had been renegotiated, even though this one event cannot be attributed to leading to all the shifts I observed.

Other products revealed that class norms had been re negotiated. Besides substantive ideas such as Dimitri's model for chemical change of a filament, these products included assuring everyone's right to disagree, deciding what authority would determine an idea's correctness, and finding ways as a group to agree how to resolve conflicts. In addition to these shifts in discourse, we also returned to Dimitri's idea that had

been rudely ignored and gave it and Dimitri the recognition they deserved. The next section explicates the other products that showed, at least temporarily, that norms had been renegotiated.

Assuring Everyone's Right to Disagree

We had come full circle on this journey examining chemical changes as the discussion topic progressed to Dimitri's idea about filaments and magnesium. We arrived at a place where we had to make decisions informed by evidence that was only indirectly related to our models. In order to progress in the argument, students forwarded their rights as individuals to not be persuaded by the majority, but to retain the right to disagree if they were not convinced.

188	Tr	Number four magnesium in air/Um let's see. Brent you haven't had an opportunity to say anything yet today
189	Brent	I don't want to say anything.
190	Kristy	Okay Brent.
191	Tr	Get us started on magnesium in air Number four.
192	Kristy	Here (hands him the group sheet) number four.
193	Samuel	All you got to do is read.
194	Brent	All right. It's chemical.
195	Tr	You say it is chemical?
196	Brent	Yeah.
197	Tr	Why?
198	Brent	Why?
199	Tr	Yep. Why?
200	Brent	Because it burned up.
201	Tr	Because it burned up.
202	Brent	'Cause it's a powder when it burns.
203	Tr	Anybody have a different reason?
204	Samuel	Erin does.
205	Kristy	Erin has a good reason.
206	Tr	Erin you're just pouncing on it.
207	Erin	It's a, I think it's a physical change because the, um, when you burn it doesn't actually like dissolve. It's, it just changes its form into another form into the ashes, the white ash.
208	Brent	Yeah, but can you get it back to its original form?
209	Samuel	Sure.
210	Erin	No, but...
211	Brent	Well, then there's your answer!

212	Samuel	Whoa, Whoa, Whoa!
213	Erin	Sorry, it's my own opinion....But anyway...I think it's physical because it changes into dust. It just changes the form.
214	Micah	I disagree with Erin.
215	Tr	Okay, you disagree with Erin and a couple of people disagree with Erin. Let's go back to Brent.
216	Erin	That's my opinion so...
217	Dimitri	No! She's wrong!
218	Tr	Just a second.
219	Dimitri	She's wrong.
220	Tr	Just a second.

There were six different comments in which students, not me, defended individuals' rights to choose what to believe (208, 213, 214,216, 217, 219). Unlike Cindey who had offered to simply agree with the majority, Erin chose to retain her right to disagree. Erin's abstinence from consensus did not inflame the rest of the class as Cindey's actions had (154-178). While Cindey's promotion of her idea and contributions had drawn hostile reactions from seven other students, Erin's disagreement with Brent had drawn attacks from only two others--Micah and Dimitri, the originator of this idea. Perhaps students recognized her agreement with the use of evidence to support ideas and decided to leave those who directly disagreed with her to do the work. She was not departing from the agreed process, she was disagreeing with others' ideas while conforming to the rules of arguments. Instead, other class members outside the disagreement allowed the disagreement to continue, as if to signal that this was what we were to accomplish.

The promotion of individuals' rights to disagree, indicated that our progress was still heavily influenced by the underlying agenda to maintain social status in the class. Brent made an

effort to avoid a social risk. Normally a very quiet student, Brent reminded me he would rather not say anything (189). I increased the level of my power from an invitation to participate to an understood directive, "[You] get us started on magnesium and air. Number four" (191). I placed Brent in a position he did not prefer. Erin also found herself at risk of losing social status and mockingly responded with, "Whoa, whoa whoa" (212). Dimitri used a tactic he had used many times before to silence opposition and to steal the floor from his opponents. When Dimitri wanted to interject his disagreement, he chose to interrupt in a shouting voice, "No! She's wrong" (217)! While Micah politely indicated his disagreement with Erin, he regularly chose to act as an outsider to this community, hence indicating he was relatively unconcerned with status or recognition from the group. This would support that Dimitri's loud and rude interruption of Erin was both social and intellectual.

Determining the Correctness of An Idea

With regard to the ideas promoted, we still had at least two conflicting interpretations of the filament burning out. Throughout this renegotiation, we arrived at a way and a means to disagree, and a uniform position of where our community could discover answers to questions about the world. Brent's response carried clarity and conviction. He formulated a position, "It's chemical" (194) and used evidence under fire to back his claim, "'Cause it's a powder when it burns" (202). In earlier discussions, comments such as Erin's, "I think..." were left for

me to clarify and relate to the previous speaker's position (68, 73, 117, 131, 151).

This was not so with Brent. He clearly heard the challenge of her explanation and proceeded to argue why his position was supported by the evidence (209-213). Brent's deferment of authority had little reference to the social support for his idea. Instead, he was implying answers can be found in attempts to explain all the available evidence and not just some of the evidence. "There's your answer," (211) suggests his answer is found in the world. Authority over whether her or his answer is correct is found in the world and not in the group's social consensus or in the agreement with the teacher's predetermined correct answer.

After reaffirming everyone's right to disagree as long as their reasons were based upon evidence, I orchestrated the discussion around a difficult set of ideas related to indirect evidence. I used my leader influence to demonstrate there was good reason to believe that air "sticking" to the filament would change the filament to ash. Karlton's cooking pots and water running off of plane wings had invited indirect evidence supporting unbelievable ideas such as rainstorms in the bathroom or invisible air sticking to filament. This continued and the group discovered a way to decide how to resolve the conflict that does in fact represent what scientists often do.

220	Tr	Brent had a reason. Do you remember Brent's reason for saying it was chemical?
221	Samuel	Cause you can't bring it back.
222	Tr	That's very good Samuel that's very good.
223	Erin	So...
224	Dimitri	I know how to tell...

225 Kristy (to the teacher) You're cuttin' on him (Samuel) and then he goes, "That's very good Samuel."
226 Erin Which one can't you bring back?
227 Tr (defending my actions) That's exactly what he said.
228 Erin Physical?
229 Tr He said you can't bring it back.
230 Erin You can't bring physical things back?
231 Dimitri I know how to test it. Put a current through it.
232 Tr Why? Tell us why that test would work?
233 Karlton Okay go get it.
234 Dimitri Because electricity would flow through the magnesium, but if you put in on the ash it wouldn't flow through it.
235 Tr That's a good test! That is a good test.
236 Tasha Good Dimitri.
237 Tr What do you think about that?
238 Samuel Well, that's going to be real hard unless you have the ash on...you're going to have the ash like perfect laid out before and after you burn it.
239 Erin What did you say Dimitri?
240 Dimitri You put electricity on it when you burn it. And then see if it goes through. It'll tell ya'.
241 Tr We could certainly try that. Even if it's a small...
242 Erin That'll tell you if it's chemical or physical change right?
243 Dimitri It's physical then it's gonna' go through it but if it's chemical it won't go through it.
244 Erin O-o-o-o-h!
245 Tr What do you think?
246 Erin That's a good experiment!
247 Tr It is.
248 Karlton A way in which you could check if it goes through it is to just check it with and Ohm meter for resistance.
249 Tr (to Karlton) Resistance. Kind of like a volt meter. We could do that. Okay.
250 Tr Erin what do you think about that?
251 Dimitri I think I should get my C moved up to a B after that.

The group on both sides of the argument had agreed upon a way to resolve the conflict. The factions had agreed this test was generated by Dimitri and Karlton was going to at least help decide who was correct. The product of the argument was not a final correct answer, but rather a test to discover. Not only did they spontaneously generate a scientific test, both factions knew in advance how the results would verify or refute their positions. Dimitri knew electrical conductivity could show if a substance was the same or not (240). The elegance of Dimitri's test was compelling to both sides members, as Erin's enthusiastic, "O-o-oh," (244, 246) revealed. Now they simply had to perform the test.

There was a shift in the nature of how questions were answered. Students' responses included more than their personal beliefs. In sustained dialogue around a single idea students' responses possessed elaboration and relationship to others' ideas and evidence (234, 240, 242, 248). Each response included an idea initiated by another student, a link to the scientific idea (chemical changes), and a relationship to the original question (magnesium burning). The answer to the question, "Is it a chemical change?" was not resolved with a simple "yes" or "no." The answer was discovered in a test producing evidence to solve the dispute.

Throughout the power struggles, their incoherent use of the ideas and use of rules for their benefit, their insults and bickering, and the rest, we finally had a grasp of what we were trying to find: a good way to test whether Dimitri's model of

air sticking to the filament was correct. But we emerged with something more valuable than this test; we experienced an evolution as a community in which we could disagree and collectively design ways to test the validity of scientific explanations.

This was the culminating event that told me I was on the right path to helping these students acquire a secondary discourse useful in collectively solving problems about the world using evidence. Students no longer looked exclusively to me for the answer. Neither did they rely soley upon my social direction to ask such questions as, "Why?" or, "How do you know?" or undermine my efforts to sustain these types of discussions. When Erin needed further clarification or explanation, she asked. We had come a long way from soliloquy statements of, "I think that..." where students channeled their comments through me to receive clarification or affirmation. They were well on their way to solving problems through discourse around shared experiences.

DISCUSSION

We Made Progress

We had renegotiated, at least temporarily, a different set of norms by which we could operate and by which to live and be faithful. These norms allowed my students to navigate through discussions and me to act more like the resource facilitator I envisioned. In a single class period my students' talk shifted from isolation or antagonism toward discussing with one another,

and I in turn responded to it and my actions and posture changed from those of a tense and serious mediator to those of a relaxed interested facilitator directing discussion. My actions included drawing students into participation, halting interruptions, and funneling their questions among other students who had offered evidence to argue their points. I was not only teaching them how to be polite, but at the same time how to use evidence to support a claim.

We were adopting a way of managing a class that did not fix the problem nor functioned as a template I could use to make correct judgment about all the appropriateness of their actions in all situations. This way was more a rudimental means a teacher and students used to begin agreeing upon how to build some discourse recognizable to both sides as progress. Part of the reason my rules and enforcement were not a "solution" to the problem was I still made mistakes and had unanswered questions about how to engage my students. Another reason this was not a solution was the interactions were still recognizably driven by students' agendas of alienation, social status, and the establishment of what work we would accomplish. Inherent in our struggles were issues of how to be fair, who and what counts as authority, and what we wanted to recognize as contributions.

Still, my rules did not bring about everything I intended. My students continued to use my rules to get what they wanted. From their inception, they attempted to discover ways to meet their agendas. With regard to alienation, Samuel still sought to separate himself from class activities (65) as did Brent

(189) and Cindey (179) for reasons related to their social status in the class. Social status had also motivated to buy into my set of rules to achieve either their agendas. Cindey knew I would give her a warning before I would call her parents. She interrupted and resisted my efforts until she felt danger was eminent (92, 102, 104). Samuel knew he could get even with Kristy and Cindey by making me enforce my set of rules (87).

My students participated under my rules of discipline with an understanding that there were also ways inherent to meet their agendas. I used power to set rules and keep interactions civil, but realized students really wanted to meet other agendas. Cindey still wanted to maintain her social status without dealing with arguments about the world; Samuel still wanted the right to lash out at Kristy; Dimitri still wanted to use the rules to improve his status; and Brent still wanted to be left alone. I did not change any of this. I interpret some of the progress to the fact they were able to recognize ways in which their agendas could be met and why some of my expectations could be recognized as products of the class they could contribute. The agendas did not go away and this class was a long way from a perfect, cooperative, and sustained discourse, but it was different.

Even though I did not eliminate the contrary agendas, I did learn a way to renegotiate how they would interact that I found acceptable. Cindey may not have learned *why* she should be polite to others, but she was quiet enough for me to facilitate a significantly different dialogue in the class. Though she

negotiated to stay out of trouble for not following the rules, the end result was that students were able to discuss Dimitri's idea without interruptions. Although they had not resolved all their differences with one another, rules were a welcomed change and empowered us to accomplish more than any of us had expected.

Rules Did Not Stifle Students

I had set my sites on a community that operated similar to a scientific community once the "chains that bound them" were broken. I had entered this classroom with a plan to engage students in a discourse that would spiral into interesting and productive scientific investigations about the world. I envisioned removing traditional barriers of teacher control and classroom influences--influences I felt inhibited inquiry--, sitting back and watching the community mature. Hoping their influences upon one another would drive the community's progress to be more scientific, I planned to use my influence to suggest, motivate, and question students' actions.

However, my students did not spontaneously act like a scientific community. We were not swept away by interesting questions and arguments about the problems I posed for them. Some students resisted any participation in what I modeled as scientific activity. They interrupted and insulted one another, and bargained away the expectations I placed upon them. Students were not driven toward cordiality or productivity on the basis of influences inherent to this group. They did not immediately embrace or construct the types of interactions I wanted. I had anticipated that any strong use of authority

would be met with great resistance. I was wrong. In fact with the students help and suggestions, I was able to accomplish more than I had in the past.

Although not necessarily by design, classrooms are places where social issues impose on an already full agenda. I needed to enforce respectful treatment of peers, not only because this is part of socializing students, but also because respectful treatment helped me accomplish my educational goals. When left to their own governance, my students did not create a productive environment or one void of personal attacks. They were not adverse to resorting to rude comments or actions to keep from hearing an opposing perspective. Neither are scientists. The difference was I could not, in good conscience, allow students' expectations drive all our interactions.

Throughout this process of changing the rules, I had anticipated the students' participation would change and they would need to learn to interact with one another differently. What I had not considered was how much *my* role would change. I had to consider new aspects of my teaching that had missed the drawing board of my original vision. After all, *I* was not the one interrupting other students, getting off task, or insulting people. Instead, I had only thought about how I was going to have to be firm and confront rude individuals. I did not consider how my actions of stopping class, telling students how personally disappointed I was in them, and inviting them to rejoin class conversations had been interpreted. I had practiced some confrontational styles that made me appear quite

weak and left me at the mercy of my students intentions. I had to learn to be comfortable exerting large amounts of power over students who had the potential of responding in a hostile manner.

I also had not thought about what would happen if I made a wrong call. I had to learn how to be corrected in front of my students and by my students. I wanted to have sole authority over judging the appropriateness of students' actions. However, I did make some wrong calls and I was influenced by students' demanding consistency and fairness. I had to learn to juggle the pursuit of students' ideas and the just enforcement of disciplinary rules. Confronting students in the presence of highly critical peers was no trivial task.

Teachers are given power in the classroom. For each act of resistance, there is a rule granting teachers the power to control their students' thoughts and actions. Rules are expressions of power that are necessary to meet the daily challenges of conducting class. My students expressed, in many ways, the need for me to exert more power over their peers. Though other student groups may or may not request the same action, there is a real need for exerting power in any science classroom. Teachers are charged with maintaining appropriate social norms as well as challenging students to think differently about the world.

While scientific communities are void of sole proprietors of control and influence, classroom progress depends upon teachers controlling much of members' participation. I needed

to intervene and exert power in ways I had not foreseen in my original vision of classroom interactions. My knowledge of control, however, was significantly altered by such events as these. I needed to distinguish my role of authority over the subject matter from that of their behaviors. Not only did I find understanding control in these ways necessary, I found separating the two was pragmatic. Control over students' behaviors and scientific productivity could be achieved to some degree while still enhancing the intellectual freedom to investigate their ideas.

My students and I had come to understand teachers' control and use of power differently. I wanted to change students' expectations of how teachers and students should interact about the world. As a result of removing correct answers, requiring students to police themselves, and other revisions in the traditional role of teacher as authority, I challenged their existing beliefs about learning as well as my own. What precipitated was a full renegotiation of classroom expectations as a group. It pressed me to reconsider what actions and rules would support the vision I held for my students. In an attempt to teach better than I had in the past, I had to define when it was intellectual responsible to leave students to their choices and when I needed to intervene.

CHAPTER 5

OVERVIEW.....184

HOW FAR WE HAD COME.....187

INSTIGATING ARGUMENTS FROM EXPERIENCES AND PERSONAL BELIEFS.....189

AN ARGUMENT UNFOLDING.....193

Receiving Recognition for Participation.....194

Remembering the Rules.....196

Hearing Evidence to Reach a Group Consensus.....199

Two simultaneuos but different arguments.....201

New roles for some.....205

Resolved?.....207

MAKING SENSE OF WHAT WAS SAID.....208

Interactions Were Partly Intellectual Struggles.....209

Interactions Were Also a Social Struggle.....210

WHOLE GROUP ARGUMENTS AND MY STUDENTS.....212

ARGUMENTS AS SOCIAL QUARRELS OR SOMETHING MORE.....215

INTERVIEWS REVEAL INDIVIDUAL CHANGES.....216

DISCUSSION.....233

CHAPTER 5
How to Decide Who is Correct: Analyzing Classroom and Individual Conventions

Well, my classmates are making me feel like it's nothing.-Cindey

OVERVIEW

In Chapter 5, I argue students' social struggles not only impose upon class, but often drive scientific discussions and, in some cases, social and intellectual struggles are inseparable among students. Group discussions were ways for students to simultaneously improve their status and to solve problems. Using their scientific prowess, students gained social status, which they used to divert the argument away from overwhelming evidence against their idea. Also, as a result of instruction, their abilities to argue scientifically were changed. Students used their newly acquired argumentative skills to influence the progress of the task and class procedures to increase their participation in the task to help them gain social status. In the end, it was difficult to distinguish within a group discussion when a student was convinced by the evidence or whether the social politics of the class persuaded them.

By the time I finished collecting my data, I orchestrated more group discussion around the students' ideas because as I listened more to their arguments, I realized they had acquired the ability to use evidence to support their claims. Also, I noticed they did not hesitate using their newly acquired skills to meet their social agendas in the classroom. They used their

arguments, won or lost, to keep some sort of social score of whose comments were valuable. Even though my students used evidence more often in their explanations and in defense of their beliefs, I continuously fought against them throwing in the towel whenever they felt they were socially outnumbered. There were only a few students such as Cindey who spoke up and expressed that their ideas were not talked about enough and Cindey observed her classmates' comments concerning others' ideas. Of all the possible reasons why students did not discuss others' ideas, Cindey concluded that her idea did not receive much attention because it was less valid than others, as illustrated below.

1	*Cindey*	*I have a question. Where does mine [idea] fit in? Because you guys are always talking about Micah and Dimitri's.*
2	*Brent*	*Yours is dumb, dude.*
3	*Tr*	*That's a good question. That's a great question. The reason I address that is because Micah's and Dimitri's are more closely related and yours*
4	*Cindey*	*It's way out in left field.*
5	*Tr*	*No it's not out in left field.*
6	*Dimitri*	*Yeah, basically it is.*
7	*Tr*	*It's not because someone has to prove...Dawanda you're warned now, too. It's not out in left field. It's just as valid until someone can show that there's good reason to throw it out.*
8	*Dimitri*	*(blurts out) I can give you a reason a good reason to throw it out.* *(class giggles)*
9	*Tr*	*All right, well, not right now.*
10	*Cindey*	*Thanks Dimitri!*
11	*Tr*	*And its not just if Dimitri thinks it's wrong, it's whether the whole group thinks it is.*
12	*Dimitri*	*Once they hear what I have to say then you'll...*
13	*Cindey*	*Okay, I still think I should get some credit because I have the guts to...*
14	*Dimitri*	*You will!*
15	*Tr*	*There's good reason to think that your idea is at least partially right.*
16	*Cindey*	*Well, my classmates are making me feel like it's nothing.*

17	*Dimitri*	*Can I, can I say why?*
18	*Tr*	*No you can't. Wait.*
19	*Erin*	*It's great Cindey...You're an* achiever.
20	*Jeanne*	*An* over *achiever! (laughs)*
21	*Dave*	*Warn Jeanne, she deserves it.*

Social importance is common among members of a classroom community; the classroom environment is rich with explicit statements and implicit messages about students outside the classroom and what agendas they will pursue. In a single class hour students may focus their energies on learning subject matter, seeking ways to meet teachers' expectations, learning appropriate social skills, or competing for social recognition by their peers.

Unfortunately, in my class, one of the most important agendas for students was establishing their status amongst their peers. Usually, this recognition was attained through competing with one another or resisting general adversaries such as school policy. I did not explicitly state I wanted them to compete for social status in my class; they brought that expectation with them. Similar to Cindey, many students interpreted my class organization as an appropriate forum to advance their social status as my activities were filtered through a lens making striving to be socially superior a natural outcome of daily instruction.

Cindey was convinced her class participation was supposed to improve her grade and perhaps even status. Also, her classmates convinced her she was not achieving the social status she believed she deserved. Cindey may have interpreted correctly, but her classmates may have been telling her her idea

was less valid. Despite my efforts to ward-off personal attacks and maintain a focus on evidence, Cindey's classmates criticized her with slams about her idea being "out in left field" and with backhanded compliments of being an "achiever." Cindey received the not-so-subtle message from her classmates--in this environment, there are social ramifications for being wrong.

HOW FAR WE HAD COME

Upon recognizing students felt it necessary to cut others down to build themselves up, I developed a structured set of rules aimed at reprimanding students for insults and diversions. These rules enabled me to focus more on the substance of what they said and since establishing these rules, generally, the class progressed towards solving problems instead of managing the distractions and social outbursts that impeded our discussions. As a whole, the class, accepted and abided by the class rules and recognized some of their distracting behaviors such as personal attacks and immediately looked to me for a response. Similar to Samuel, they learned what the rules meant in this context and when I consistently enforced our rules. Still, because our experience together was such a roller coaster of good and bad days, I was at a loss at how to determine how far we had come.

Quickly, I learned how to read my students' responses to one another in order to realize someone insulted another or they were diverging from the subject. As a result, using emotional components of the groups working in different parts of the room, I assessed when students were actually doing what I asked them

to do. So, when students laughed loudly or got extremely hostile during small group or lab assignments, I usually guessed they had strayed from their path of discussing and solving scientific problems and instead were discussing social agendas such as telling stories or making personal stabs at one another.

Because of a more general idea I held about the way scientists work, I asked students to stay away from social competition. Therefore, my rules about personal attacks were tightly tied with my vision of what scientific discourse should be. Rules were necessary because the scientific arguments I wanted students to construct looked different from the arguing I witnessed from my students in the beginning of the year. I had thought that their arguments and explanations needed to be free of barbs and personal attacks establishing authority based upon "Who said what?" Scientists did not work like this. Instead, if they did not agree with one another, they tried to show one another wrong and letting the evidence speak for itself.

In essence, my rules were an over-simplified attempt to guarantee the safety of students engaged in controversial arguments about their personal beliefs. I had hoped that these rules would help clarify when students were engaged scientifically and when they were just jerking on one another's' chains. For example, if they insulted one another or diverted the conversation, that was bad and they were warned; if they listened and talked about someone's idea in a way that used evidence to describe its validity, that was good and they were

praised. I had also hoped that these rules would help my students to act like real scientific communities by using scientific experimentation and gathering evidence instead of using personal claims of expertise, humiliating insults, or other social persuasion if their ideas were attacked or overlooked. There did not seem to be much middle ground for me on what a scientific argument looked like. With my ideal of a rational scientific argument within my grasp, I pressed on and asked students to use evidence to argue with one another.

Still, I sensed some social tension was keeping me from seeing what real changes had occurred in their thinking processes. I heard students say, "Well I think that," or "There's no evidence to support that" and I took these as general positive signs they were moving forward. Yet, in the midst of my data collection and other commitments, I was unable to thoroughly analyze their social interactions. However, I continued to press forward, basically on gut-level responses from the class and the limited viewing of tapes and writing about the teaching and the learning that had taken place.

INSTIGATING ARGUMENTS FROM EXPERIENCES AND PERSONAL BELIEFS

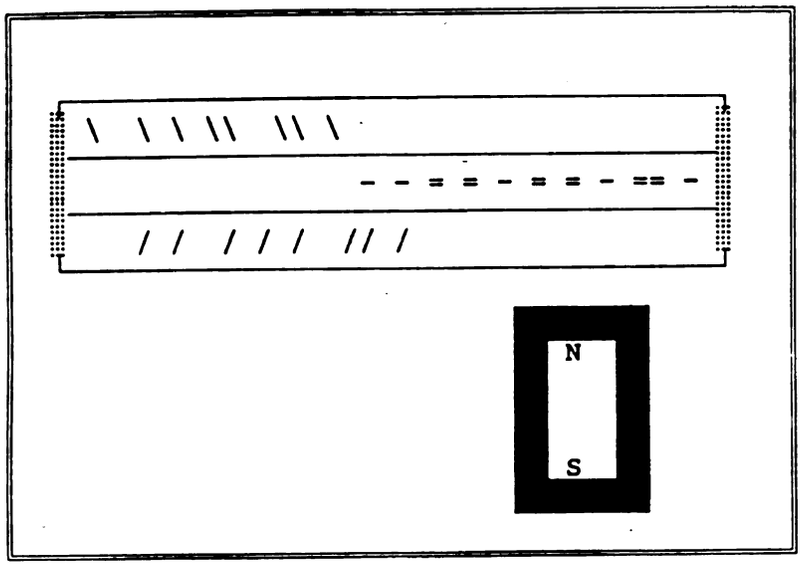
While I thought my students progressed in constructing arguments based upon using evidence and gathered data, I simultaneously discovered different problems having personal significance for them. Our class addressed problems that scientific ideas were used to help solve. Their engagement in daily activities increased along with their outpouring of ideas and interests.

One day, I heard Erin complaining about her audio tape and how it had been damaged while sitting on her speaker at home. As she described what happened, several students offered explanations. After students ran several of their own tests with tape recorders, tapes, and magnets, I asked them for their educated explanations of how Erin's tape was erased. I soon realized many students were still thinking quite differently about Erin's problem; they were miscommunicating about some fundamental ideas central to solving the problem. After Dimitri became exasperated with people telling him, "That's over my head," he asked me, "Can I go to the board?"

Dimitri described metal pieces in the tape storing the music. He reasoned that because the tape had two sides, there were at least two arrangements of these iron pieces and they had to be moved away from the head in order for the magnet to erase the sound. Because the pieces had to go somewhere, his diagram included a "center lane" where the iron pieces moved to so they would not be "heard" as the tape passed the head (Figure 1).

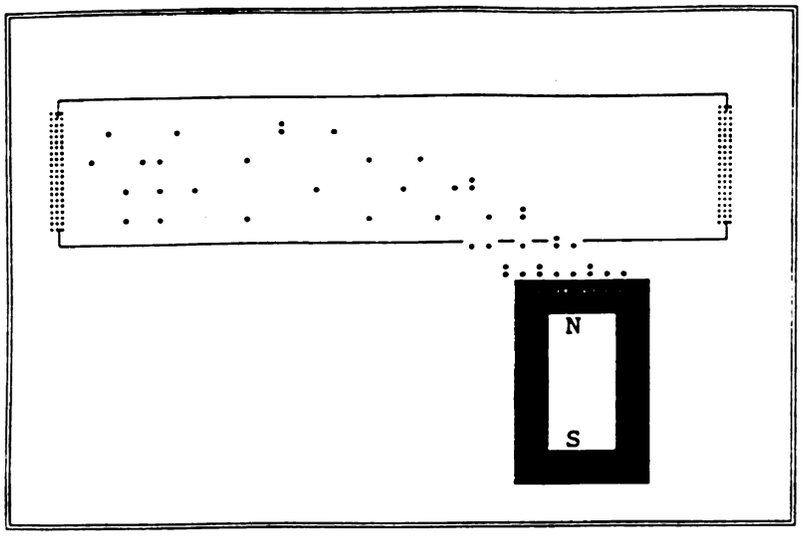
Everyone heard Dimitri's idea, but not everyone agreed. As the group discussed their different ideas, I frantically wrote down notes trying to capture some contrasting models other students verbalized. Cindey's model differed from Dimitri's in that she thought the metal particles were lifted off the tape when the magnet was brought near. Accordingly, a tape would

Figure 5.1. Dimitri's Model



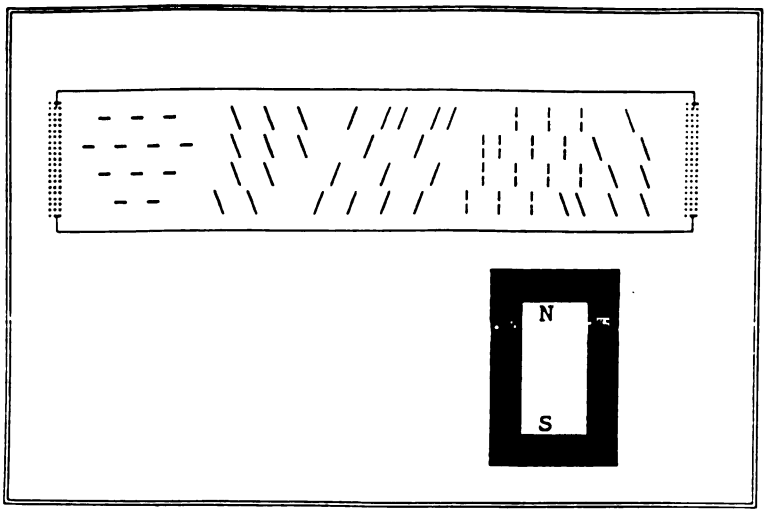
erase when placed on top of a speaker because the magnets inside a speaker (we tore speakers apart to see this) would "suck" the metal out of the tape (Figure 5.2).

Figure 5.2. Cindey's Model



Micah's model differed from both of these previous explanations. He did not think the metal pieces moved at all; instead, the iron pieces in the tape rotated like a compass needle in order to make the pattern that was "heard" by the head of the recorder (Figure 5.3).

Figure 5.3. Micah's Model



Because several different models evolved, this was a great opportunity to treat these ideas like theories a scientific community investigates and debates. I drew these models on large pasteboard placed on the chalkboard, so students could better visualize what the others said to give these individuals ownership of their ideas, forcing them into a position where they had to use evidence to support their argument. When Dimitri immediately proclaimed the others were wrong, I stopped him and told him all the ideas were possible and we had to use evidence to find out which model best explained all the events we experienced. The students formed a circle with their desks and formed sides for the argument.

When the argument broke out concerning who was right, it became evident Dimitri and Cindey were not going to pull punches trying to convince the rest of the class. They both knew there was metal in the tape because the tape attracted the magnet. But they differed in that Cindey thought the metal was lifted completely off of the tape when it was erased, while Dimitri thought it simply got pushed to the middle where it could not be "heard."

AN ARGUMENT UNFOLDING

In this section, I chronologically extract excerpts from an argument the students commenced in the context of a single hour. The format was a class discussion in which all members were seated in a circle and were asked to share their findings and draw conclusions. I introduce important aspect of students' discourse so readers can recognize, develop these categories with examples, and offer an interpretation of the students' participation with respect to two general agendas students developed. Finally, I explain the implications of the types of discourse students engaged in with respect to growth as a scientific learning community.

Throughout the class discussion, I noted students introduced basically three types of comments. Students tried to 1.) solve the problem, 2.) improve their status, and 3.) change the procedure of how the class came to a conclusion. The majority of comments I heard in this argument promoted two general agendas; students used their participation to 1.) establish the work of arriving at an answer, and 2.) compete

for their status in the class. Although it was not clear whether they were meeting one or both of these agendas, their comments were best understood when both agendas and the agenda resistance and alienation were kept in the forefront of my students' interactions.

Receiving Recognition for Participation

21	*Tr*	*So, who wants to start off the group discussion? I think Dimitri is just dying to tell Cindey something. Now this is important because...*
22	*Cindey*	*(Interrupts) He's gonna tell me I'm wrong and I don't want to hear it because I'm always right. (Looks to teacher) Just kidding.*
23	*Dimitri*	*I KNOW you're wrong. I think she's wrong because if that was the case then the tape wouldn't stick to the magnet twice.*
24	*Micah*	*And also, it would suck all the metal particles off. You wouldn't be able to record over it again if it sucked all the metal off.*
25	*Dimitri*	*Right.*
26	*Cindey*	*Well maybe it just moves them around a little bit.*
27	*Dimitri*	*Well, yours says that it takes them right off and puts them on the magnet.*
28	*Cindey*	*Well, maybe that's not exactly what I was saying.*
29	*Dimitri*	*Well, tell him and have him go fix it (poster I made of her model.)*
30	*Cindey*	*(To Tr) I think that maybe it moves it around a little bit and gets all screwed up.*
31	*Dimitri*	*(under his breath to Cindey) Basically your trying to cover your...*
32	*Cindey*	*Shut up Dimitri!*

This group discussion was mixed with two distinct agendas. Cindey lobbied for her social position while Dimitri defended his idea with evidence. Because Cindey's goal was very different, she began her defense before Dimitri could launch a first strike (22). However, when confronted with evidence her model did not clarify, Cindey tried avoiding being corrected in front of her peers (26, 30) by telling me, with a sheepish grin,

I drew her poster wrong. Cindey knew the social ramifications for being wrong.

Dimitri stated why he did not think Cindey's argument could account for all the evidence. His argument against her position was directed at the need for a model that explained how a tape could be played, erased, and re-recorded (23). Cindey's model could not account for these activities and he knew this; however, Dimitri did not appeal just to class evidence because he used evidence everyone else had not witnessed.

Dimitri lobbied support for his side as he made his case; when he offered evidence he also emphatically stated he KNEW Cindey was wrong (23). One interpretation of Dimitri's position was he was making a case for stating the evidence and letting the class decide. However, Dimitri's comments may not have been objective and impersonal. Another interpretation of Dimitri's comments was he was aware of Cindey's interest in popularity and proceeded to launch an attack on her idea with this agenda in mind. Dimitri initiated the discussion arguing Cindey's position could not explain all the evidence the class had seen. He offered Cindey an opportunity to correct her position (29), but when she showed she was not going to play by the same rules he called her bluff.

Notice Cindey knew what Dimitri meant and could even finish his sentence (32) as he tried to reveal her untenable position. She temporarily squelched Dimitri's attack (32), but his emotional conviction was felt by all of us; Dimitri was going to do everything to make Cindey publicly admit she was wrong.

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This social adversarial perspective accounts for more of "why" Cindey and Dimitri acted the way they did and sheds light on the social fabric of the classroom culture that is otherwise left out along with a discussion of simply the ideas of this argument. Cindey tried playing strictly a game of social popularity that meant getting as many people to think her idea was better than the others' competing with her. She sensed her vulnerability in front of the class and twice tried to interrupt the discussion to take the sting out of her battle with her adversary (22, 32). On the other hand, Dimitri believed that this game of argumentation was played by staking out a solid position and throwing criticism at another's idea.

However, in several scenarios, Cindey, Anthony, and Dimitri attempted to change the progression of the task to improve their status. Cindey asked me to change what was written about her before she was publicly told she was wrong (30). Anthony told her to go ahead and change it, as if to communicate he could win the battle anyway. Dimitri combined his ability to argue with evidence with his desire to bring Cindey down a notch.

Remembering the Rules

I had hoped students would give their reasons and concede if their model was not accepted by the class, but I felt the contention among them and again tried to model an alternative way to disagree. Also, I recognized this discussion was the beginning of an argument that could be quite substantive and I wanted to get us started on the right foot. Wanting my students to manage their own disagreement, I asked them a general

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question reminding them of the other ways to correct one another, but they did not take me seriously in my attempt to defuse a potentially volatile situation, so my question must have sounded too transparent to evoke a constructive response.

33	*Tr*	*What do we do with an idea that's not the best answer? Do we rip on it and tell the person...*
34	*Dave, Karlton, Brent*	*"Yes!"*
35	*Cindey*	*That's what they were doing.*
36	*Tr*	*No we don't!*
37	*Brent Dave, Dimitri*	*"Yeah we do!"*
38	*Dave*	*Oh that's crap!*
39	*Cindey*	*I don't see none of your guys' answers up there, Karl-teensie-weensie.*
40	*Karlton*	*I haven't been here... inaudible.*
41	*Tr*	*What we should do instead...*
		(Class jeers)
42		*...is to say that one is less useful than the others...*
43	*Cindey*	*What did he say? Bite me?*
44	*Dimitri*	*(nods)*
45	*Cindey*	*That's not appropriate Mr. Yerrick.*
		(Whole class is laughing)
46	*Dimitri*	*(Recounts what we all did) You guys are over there mumbling somethin' and we all go, 'OOOH!'*
47	*Cindey*	*I don't think that was very nice.*
48	*Tr*	*Karlton you..*
49	*Karlton*	*...are warned.*
50	*Tr*	*...and Marcus and Dawanda and Cindey and Dawanda are all warned.*
51	*Cindey*	*Um, no excuse me. He just told me to 'Bite me.'*
52	*Dave*	*They were warned already, buddy.*
53	*Cindey*	*I don't think that was very appropriate for this class.*
54	*Dimitri*	*Okay. Onward. Go on.*
55	*Tasha*	*On. go on.*
56	*Dave*	*Onward March!*

While I intended my question as a statement (33): *"We SHOULD disagree with one another in a different way. Someone tell me a better way that Cindey and Dimitri can disagree."* My students made jokes about the question responding as if I asked: *"What are your normal responses to someone you do not agree*

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with? Is this normal for Cindey and Dimitri?" Several students responded in jest to my question (34, 37), while Cindey appealed for sympathy in front of the group (35). Karlton, Brent, and Dave had not yet committed to arguing about this problem nor revealed who they agreed with, but they seemed quite entertained by the exchange.

Though Dimitri was one of the students who chimed in with them and was one of Cindey's primary adversaries, she did not confront him about the joking remark. Instead, she chose Karlton who was a more vulnerable member of the class (39). He was a loner and an outcast of the class. As a rule, no one talked to him; she knew if she told Karlton off, no one would defend him and she could continue to accomplish her agenda of raising her class status.

Because I was concerned with how students disagreed with one another, I missed this interchange between Cindey and Karlton. However, others did not. While my question was met with jokes (34), Karlton's response of "Bite me" drew instantaneous recognition from several students who visibly turned to me with "Ooohs" and "Aaahs" before I could finish my sentence about how we should act (41). The resulting emotional tension provided evidence of the difference in social expectations we have for disagreements. Dimitri even recapped for everyone how I had missed their attacks altogether by focussing on some peripheral issue (46).

Once again, Cindey tried influencing the students to elevate her social status by using the class rules and procedure

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to her advantage. Knowing insults and foul language would be acted upon by the teacher, she reiterated, in a loud voice, what Karlton mumbled and asked me to take action against him (43,45). Cindey thought this side-tracking would vindicate her and her provocation was less severe than Karlton's response; therefore, he ought to be punished more than she.

Once this diversion was over, Dimitri tried moving the discussion back to its original course favoring his position. He suggested, and he was echoed by two other students (55-57), the class process should move past Cindey's plea for abdication.

Hearing Evidence to Reach a Group Consensus

Shortly following this ugly confrontation, the discussion moved onward. Soon others tried finding out how Dimitri could be so sure Cindey was wrong.

57	*Tasha*	*Cindey, I don't understand what you're saying...*
58	*Cindey*	*(interrupts) It's wrong because everyone thinks its wrong. So it's wrong.*
59	*Brent*	*It is.*
60	*Tasha*	*Well explain it to me--even if it's wrong.*
61	*Cindey*	*I thought that when they took the tape and they pulled it across the magnet you know how metal attracts to the magnet.*
62	*Tasha*	*Oh all right, like when it's erasing?*
63	*Cindey*	*It was pulling stuff off of it...*
64	*Dimitri*	*Not the case.*
65	*Cindey*	*Okay!*
66	*Tasha*	*Okay Dimitri. She just wanted me to explain to her what I thought.*
67	*Dimitri*	*I know, I'm just saying...*
68	*Tasha*	*Dimitri, go for it .*
69	*Dimitri*	*I said my part I don't think it's true. I know it's not true.*
70	*Tasha*	*Why ?*
71	*Cindey*	*Well, throw it out then and explain yours Mr. Wizard!*
72	*Tasha*	*Why isn't it true?*
73	*Erin*	*How do you know?*
74	*Dimitri*	*I think mine and Micah's should be combined.*
75	*Brent*	*It's simple!*

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Two additional students, besides Dimitri, attempted to move the argument toward problem solving with evidence. Tasha requested all the ideas be made public (60, 72) and Erin demanded reasons for throwing out Cindey's model (73). Dimitri interjected Cindey's explanation of what part of her model could not be supported with evidence (64). At the same Anthony suggested his model was inadequate for explaining all the evidence (74). In a later discussion, Dimitri explained his idea accounted for the two sides of the tape, but thought Micah's idea was better because the metal did not have to move.

Dimitri's comments were more than rational recants of reasoning from both sides. Although he did try getting Cindey to argue using evidence (23, 26, 29), he also acted in ways interpreted as strategic and antagonistic. Dimitri's timing precisely coincided with Cindey's first instance of admitting the details of her position. Tasha and Cindey interpreted Dimitri's intonation resembling, "I told you so" (64) as a social attack (65, 66). They reacted to his interruption as if he had pushed the social battle too far. After all, Cindey had already admitted her idea was wrong.

Even though Cindey surrendered her position, she did not go prove herself wrong according to the rules of evidence and argumentation (58). Therefore, Dimitri's comments would be best understood if both agendas were considered. Not only was he interested in solving the problem correctly, he was also seduced by the recognition and status he would gain by using evidence to show Cindey she was wrong. As a result of his comment (64),

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Dimitri accomplished both of his intended agendas. First, he showed his understanding of Cindey's model and that the evidence used to support his position were correct. Secondly, he exposed Cindey's waffling as an attempt to obtain popularity. Cindey understood the social ramifications of Dimitri's attacks and tried to degrade him and escape the center of attention with another insult (71).

Two simultaneuos but different arguments

Other students began changing their posture and participation as they are observed Dimitri and Cindey's exchanged. Students, including Erin and Tasha, became impatient with Dimitri's indignation and abrasiveness (66) with Cindey and began asking more questions about how he was so certain. Dimitri raised his voice and several other males defended his argument of why Cindey was wrong.

76	*Erin*	*Dimitri, but how do you know Cindey's isn't right.*
77	*Tr*	*That's a great question Erin.*
78	*Dimitri*	*Because!*
79	*Brent*	*Do you see...? Dave, Brent, Jeanne (hands go up)*
80	*Dimitri*	*You know the big magnet? You know the big magnet? Here's the big magnet okay...?*
81	*Tasha*	*Okay...*

Several joined in to offer their interpretation of why Cindey was wrong; they gave two simultaneous and coherent arguments.

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82 Dimi *You put the tape on, you know how it sticks to it? You know how that says if you took all the magnet pieces off...and it wouldn't stick back to it twice.*

83 Tasha *Dimi's trying to say that...*

84 Dimi *There's no way. It's not...*

85 Tasha *...that it will only stick to it once.*

86 Dimi *That's what I said!*

87 Tasha *Did you try that?*

88 Dimi *I know, I know!*

90 Karlton *(Raising his hand) Mr. Yerrick?*

91 Dave *There's no evidence to support that the metal got pulled off!*

92 Cindey *There's no evidence that it didn't get pulled off either!*

93 Brent, Dave *Yeah there is!*

94 Brent *If you play the tape once, you'd take off that stuff and you wouldn't be able to tape no more. You'd have bought a blank tape.*

95 Brent *What's it do, replenish? Yeah, you'd see little particles all over the tape player head and you wouldn't be able to use the tape no more.*

96 Tr *Okay, I heard four different people explain why that's not the right model. But the fact is I get really lost when everyone talks at the same time*

97 Cindey *Me too.*

Following the challenge of Dimitri's reasoning, two simultaneous arguments broke out in loud voices. On the one side, Dimitri exclaimed in an exasperated tone, "Because!" Tasha, who flanked him, tried clarifying his reasoning (86). Unfortunately, Tasha was not present during Dimitri's experiment, but tried following his lead to test all ideas against available evidence. Reasonably, because she did not see first hand the evidence against Cindey's model (89), Tasha questioned Dimitri's claim.

Rather than exiting the argument and repeating his experiment in front of Tasha as he had done several times

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before, Dimitri used an aggressive posture and raised voice to tell Tasha she was not saying anything new. Dimitri's impatience and assertiveness, alone, seemed to convince Tasha his idea was correct, instead of her relying on her personal experience with evidence that refuted Cindey's position (90).

Tasha entered the discussion as an uninformed participant and her reference to her absence (89) can be interpreted as a withdrawal from her skepticism and a direct statement of her lower status as a female; therefore, her ideas were not worth considering. Because Tasha did not see the evidence, she could have accepted the reliability of Dimitri's experimental expertise or surrendered to his social status.

Across from them, Cindey challenged Brent to defend his criticism against her model. Though reasons were given why her idea was inadequate (23, 24, 83), Cindey claimed there was no evidence proving metal particles did not come off the tape (92). With much exhasperation in their voices, Brent and Dave explained how Cindey's model could not explain the lack of filings on the head or the ability to replay tapes more than once.

Although Cindey changed her tactics for demanding evidence of her critics, she was more bold about her position because she argued with less socially influential students, Brent and Dave. Brent and Dave raised their hands before talking, which indicated their social discomfort in asserting themselves. The social nature of this argument was further supported by Cindey's claim that there was no evidence proving her wrong. She

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defended (22), retracted (30, 58), restated (61), and again defended (92) her position without acknowledging evidence that was offered to counter her position. Finally, Brent reacted to Cindey's social challenge with his own social barb as he dismissed her idea, "What's it do, replenish? Yeah, you'd see..." (95). Even though this was an invitation for Cindey to defend her position again, Brent asked and answered his own question, communicating to Cindey she lost this argument.

In this exchange, students showed the intertwining of arguments and two extremes of social influence. On one side, Dimiri used his social position to convince skeptics of a scientific claims. On the other side, Cindey's ploy to acquire sympathy and social recognition pushed Brent and Dave beyond an intolerance point; she compelled them to speak up in an atypical manner and refute her claim. As a result, students simultaneously used the group discussion to improve their status and to solve problems. This clearly exemplifies classroom social and intellectual agendas encroaching upon one another..

In addition to students using arguments to fight social battles they also made suggestions about class procedure that would influence their status. Raising my hand to halt further discussion until I spoke, I announced I could not follow the two arguments; Cindey agreed she was also lost, regardless of the fact she was carrying on a direct conversation with her immediate neighbors when I interrupted (91-95). Once again, Cindey used class procedures to achieve her own social aims of not being contradicted in front of her peers.

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New roles for some

When hearing Brent speak, as he seldom contributed to substantive class discussions, I happily and encouragingly invited him into the conversation because this was an excellent opportunity for his voice to be heard above the others'. Cindey and Dimitri dominated conversations and kept less confrontational students such as Micah, Erin, Dave, Karlton, and others in the background. I gave Brent permission to state his opinion and elevated his social status above others who talked.

98	*Tr*	*So, Brent would you please start, and then we'll go to Karlton, Dimitri, and then to Micah. Could we do that?*
99	*Dimitri*	*Okay go.*
100	*Tasha*	*Okay go.*
101	*Erin*	*I think that we should...I have a suggestion,*
102	*Brent*	*Shut up! Just...*
103	*Dimitri*	*Wait till it comes to you.*
104	*Tr*	*Erin has a suggestion.*
105	*Erin*	*I have a suggestion. I think we ought to go around the room, ask everyone around the thing and ask their opinion.*
106	*Dave*	*Let's let Erin teach the class.*
107	*Tr*	*All right let's start with those four.*
108	*Erin*	*Yeah.*
109	*Brent*	*Can I go now?*
110	*Brent*	*It's kinda impossible, because you see little metal particles you first bought the tape on it and when you played it they'd go on the head, and you wouldn't hear nothin' when you tried to play it again.*
111	*Tr*	*So what would it look like if it had stuff on it If it had metal particles on it.*
112	*Brent*	*It'd be all bunched up and it would have little metal chips on the head of the tape. Not the tape, on the player.*
113	*Tr*	*And your experience is that you never have metal chips on the head.*
114	*Brent*	*Right.*
115	*Tr*	*And Karlton you were next.*
116	*Karlton*	*Okay, If there were metal chips that came off the tape when you put a magnet over it, Wouldn't it seem that if you put a white piece of paper over it that the metal pieces would stick to the paper and you'd be able to see 'em?*

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117 Tr What do you think about that?
118 Dimitri That's true too. Same point.
119 Tr Did anybody try that?
120 Dimitri Yep me and he did. It worked.
121 Tasha He and I.
122 Cindey Could you say that one more time Karlton, please?

My students understood my role in this conversation as someone who dubbed social status with a single sentence. This was evident from Brent immediately assuming having the floor gave him a more influential position than he had moments before. As a result, he yelled at Erin too, "Shut up!" (102) and asked, "Can I go now?" (109) so he could regain ground on which Erin infringed. This aggressive atmosphere proved too much for the non-confrontational students to battle alone. Brent's and Erin's suggestions about the way discussions progressed were attempts to carve out their own place for how they could participate (105).

After I interceded and clarified the social hierarchy, the conversation took a turn toward a more rational and systematic approach to presenting thought experiments and experiences that offered further evidence towards the same end--throwing out Cindey's model. Brent explained that tapes could only be used once if the metal came off (110) and that he never saw any of the metal built up on the inside of his tape players (112). Karlton echoed Brent's argument, but offered an elegant thought experiment. He proposed running a test to see if metal actually did come off the tape as it was erased with the magnet (116). Dimitri agreed Karlton's experiment was important and told the class he already tried it with another teacher and, "It worked"

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(120); metal lifted off the tape was not visible. However, Karlton's experiment was so concise and persuasive it even caught Cindey's attention (122). Overlooking that Karlton told her, "Bite me," just minutes earlier, Cindey politely asked Karlton to repeat his thought experiment.

Resolved?

At this point, the class abandoned one model--Cindey's--representing how music is stored on an audio tape. Erin accepted others' arguments as refuting Cindey's model and asked if there was any more.

123	*Erin*	*Is there any more reasons why A will not work?*
124	*Cindey*	*What's A?*
125	*Erin*	*Oh, Cindey's model.*
126	*Tr*	*Is there any other reasons why Cindey shouldn't be held up as the best model?*
127	*Brent*	*Yeah Cindey made it.*
128	*Tr*	*Dimitri you want to add to it?*
129	*Dimitri*	*I've already put in my five cents worth...I just think it's not true. It's wrong.*
130	*Cindey*	*Brent that's not nice. I think you ought to go in that room and think about what you just said.*
131	*Micah*	*I don't think it's right because that experiment that Dave was doing where he run the magnet across and taped again...*
132	*Dimitri*	*That proves it.*

The argument about Cindey's model appeared to be closed because the argument against Cindey's model convinced Karlton, Dave, Brent, Dimitri, Tasha, Micah, and Erin. Karlton, Brent, and Dimitri's evidence and backing went unchallenged for minutes and Erin invited any arguments. Brent launched one last social barb at Cindey (127), reminding her there are social ramifications for holding ideas proven wrong with little experimentation. Cindey lost, and again appealed to class

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procedures with rules for justifying her social position in the class (130).

Once again, Cindey competed with Dimitri for her social status. Brent placed her in direct conflict with Dimitri when he said that basically anything Cindey said cannot be believed (127). Dimitri could not overlook this opportunity to declare, one final time, who was the winner of this battle. When Micah described why he believed Cindey was wrong, Dimitri again offered, "That proves it" (132) in a recognizable tone suggesting, "I told you so."

MAKING SENSE OF WHAT WAS SAID

As I mentioned before, the comments I noticed students using generally fell into three categories: 1.) students attempting to solve the problem, 2.) students attempting to improve their status, and 3.) students influencing how the class concluded. Clearly, most students were interested in solving the problem.

As I returned to the transcripts and reviewed the videotape, only two students abstained from contributing to this part of class. In addition to noting intonation, capturing body language, and staking out different positions, I placed each response of this exchange into one of the above three categories and counted the number of responses that fit into each. As a result, 43% of the students' comments focused on solving the problem. Seventy-eight student comments were attempts to improving their social status; 32 of these responses were

directed at influencing how the class concluded. Approximately, 19 comments were categorized under more than one heading.

My comments varied less than the students' and focused more on the procedural component of class:

21	*Tr*	*So, who wants to start off the group discussion? I think Dimitri is just dying to tell Cindey something. Now this is important because...*
33	*Tr*	*What do we do with an idea that's not the best answer? Do we rip on it and tell the person...*
50	*Tr*	*Karlton you...and Marcus and Dawanda and Cindey and Dawanda are all warned.*

As the argument progressed, I sustained arguments by supporting the speaker through structured dialogue. My input was less punitive than when this discussion began.

77	*Tr*	*That's a great question Erin.*
96	*Tr*	*Okay, I heard four different people explain why that's not the right model. But the fact is I get really lost when everyone talks at the same time*
98	*Tr*	*So, Brent would you please start, and then we'll go to Karlton, Dimitri, and then to Micah. Could we do that?*
126	*Tr*	*Is there any other reasons why Cindey shouldn't be held up as the best model?*

Interactions Were Partly Intellectual Struggles

In many ways my class made great progress. My students acted in several scientific ways:

- Created separate, visual, and detailed models for all to see and critique. These models explained a specific event that cannot be explained to the naive observer without further investigation.
- Designed a variety of their own tests and gathered their own evidence in pursuit of determining which model best described the event.
- Decided on the rules of admissible evidence in argumentation and made group decisions about the importance of different types of evidence.

- Criticized models on the basis of their ability to explain all the evidence gathered.
- Defended, spontaneously, models and created new tests to determine unresolved questions that arose about the models.

In all these ways, I saw what Dimitri, Karlton, and other students engaged in as modeling the scientists' work. Even though this was only a small clip of the inquiry process that actually took place over 2 weeks, this substantive group argument suggested the time preceding this event was valuable time spent "making sense" of the problem in a way that enabled such argumentation. The following class periods focused on other questions that further clarified why Dimitri's explanation was also incomplete. This one conversation substantiated some explanations and initiated new questions. My students engaged in ways that increased our understanding about a question we originally could make few claims.

Interactions Were Also a Social Struggle

Despite the intellectual gains students achieved, I was perplexed by the social gains and losses that were an integral part of this activity. In the process of defending his position, Dimitri also dealt serious blows to Cindey's status. Most students, not as bold as Cindey, would have receded into the background similar to Tasha. However, for Cindey social status was important and she expressed this message in many ways. As a result, Cindey continued talking about her ideas and provoking others to participate.

Perhaps Dimitri knew attacking Cindey's status would bother her, so he chose not to stick solely to evidence. All I can be certain of is that students' social status played a large part in driving others to participate in the argument and that decisions made on the basis of social status was what I was trying to avoid altogether. Attempting to alter their agendas so they would use evidence to sort out which model described the world best and not to discover which individual could ridicule another, I polarized their positions by emphasizing the differences in their models.

However, what transpired was a social battle of Cindey maneuvering herself in and out of the focus of discussion and Dimitri shining light on her any time she showed vulnerability. Through comments such as, "Basically, you're just trying to cover your..." and "Yours is dumb dude," my students insinuated Cindey's ideas were less valid in a socially demeaning way.

Evidently, Dimitri's impeccable timing and skill were enough to strike simultaneous intellectual and social blows toward Cindey. Dimitri's timed call out, "I can give you a reason, a good reason to throw it [Cindey's model] out" (8) was met with class laughter. The other students knew it struck a blow to Cindey's status and so did Cindey, but she responded with a sarcastic, "Thanks Dimitri!" (10).

Dimitri clearly let the class know he had experimental evidence to offer the class, but his arguments about subject matter were used to win social confrontations; he used single words and phrases to convince the class he was right and

deserved recognition over Cindey. "Not the case" (64), and "That proves it" (132) were his comments carrying the intonations of, "I told you so." Even Dimitri's invitation to Cindey to change her position was a challenge for her to engage in the struggle on his terms.

Not only were arguments used to improve individuals' social status; students also used the general proceedings and procedures of normal class activities to establish their class status. Cindey's diversions to get out of the limelight, students raising their hands to influence who got a turn in a spontaneous conversation, and such comments as "Can I go now?" and "Onward, march!" were used to change the procedures of arriving at an answer served to advance one side or one individual. Although these suggestions concerned the general procedure of the class, the larger social context suggested they were also ways to elevate social status.

WHOLE GROUP ARGUMENTS AND MY STUDENTS

My students, in isolated and peer environments, acquired a new way of engaging in science through new techniques of thinking, speaking, and acting, modeling many of the discourse patterns I promoted. When beginning my study, I anticipated individual arguments would have striking similarities to my observations of group discussions and I could teach these discourse patterns to replace students' tendencies to use social influences to find answers with new ways of speaking and thinking. Earlier, I observed students getting hostile or giving empty support for their beliefs in short statements such

as, "Because!" or "My uncle said so." At this point, I believed by engaging them in problems they found important and helping them use evidence to find answers I could replace ugly arguments with cleaned-up substantive ones, ones limiting students' propensity to use social status and hostility to resolve arguments.

I was only partially right; my students did use evidence, but I had not replaced, only inserted, a new way of speaking into an already complicated mixture of agendas. I did not eliminate students' needs to struggle for social status, so they used these newly acquired skills to meet their own aims. Feeling good about themselves was important and they became accustomed to putting one another down in public to achieve their desired recognition.

Because "who you are" was tightly woven into "what you know," I wrongly thought instituting a set of rules would sort out when students were attacking others and when they were truly interested in defending their own ideas. As a result, I could not differentiate between students slamming others for their own status and students engaging in rational arguments about science. Though there were some easy calls everyone knew crossed the line, the majority of the social battles were cloaked in the context of normal class work.

There was social jockeying going on, especially at strategic moments of the conversation, that brings greater questions about whether Cindey, Tasha, or anyone for that matter, was truly convinced of Dimitri's argument or the

evidence that supported it. I did not eliminate the possibility students bought into Dimitri's way of thinking just because he had been correct before or had seemingly defeated opponents with his prowess.

While students could reveal what they thought about problems, I could not guarantee they would each come to the same conclusions if given the same evidence in another venue. For this reason, I was convinced I would never be certain whether or not my students acquired the abilities to argue and used evidence to solve problems, unless I entirely separated them from one another and conducted independent problem solving, which defeats most of my other aims.

Even though emotional outbursts were exclusively inappropriate, I orchestrated such activities in which students needed to defend strongly held beliefs simply to participate. Social slams could be viewed as a sign of engagement, albeit unhealthy ones; therefore, I could no longer treat loud, emotional outbursts with standard reprimands. I could not assume if things heated up they were talking about other parts of their lives that were inappropriate in science class. Especially after witnessing the previous confrontation and seeing the relationship between the social struggles and the intellectual juggling, I realized emotional outbursts might have been a result of students doing what I asked them, which was to share their personal beliefs about the world with one another and have their peers critique them. I had them discuss situations important to them.

ARGUMENTS AS SOCIAL QUARRELS OR SOMETHING MORE

For me to tell when students were arguing scientifically was difficult because students argued with one another for many different reasons; the distinction was not cut and dry. Often, I thought what they accomplished in the hours together was motivated by their social struggles. Arguments such as these that left a recognizable trail of developing ideas were helpful to gauge my students' collective work, but was difficult to monitor individual progress.

The social environment made it difficult for me to judge their individual growth, especially for students who did not take a lead in promoting arguments. Some of these students were easily intimidated and took ancillary roles in group discussions. Their voices served as backdrops and supporting votes, instead of as confrontational debates and often, I restated their ideas, echoed their findings, or supported them more in general discussions.

What were these students getting out of this class? Because I orchestrated a large part of class around arguments, I was not certain if students outside of the primary debaters acquired such discourse. They were not left out altogether, but they certainly had less practice than the leaders. Could students who have not acted as leaders or instigators of arguments also make tentative claims, design tests, and argue the positions with evidence? They had witnessed Dimitri and several others doing this, but could they do it themselves? Had only the leaders to acquired this discourse?

More important was the need for me to know just how much of what I was seeing in classroom arguments was mobile, taken outside my classroom. I was interested in finding out how students grappled with scientific problems without the drive of social battles. My first lessons with this group taught me their personal identity in a group greatly influenced their ability to acquire this secondary discourse. I wondered if I separate these students from this learning community, how they would approach science differently than when we had first met.

Could my students formulate arguments about the world without my help or their peers'? If they could, this accomplishment would suggest this process was internalized. It was not so much that they could apply their argument skills to any situation, but more of an ability to engage oneself in the push and pull of ideas. If my students changed the way they used scientific discourse outside of the influences of their peers who had argued with them for months, then they had acquired the ability to play both sides of a conversation. They would propose tests, find ways to generate evidence, decide what evidence was important in figuring out the problem, and draw some conclusions, not because they wanted to prove Cindey wrong, but because they had acquired the ability to engage the world differently. What were the effects of engaging students in this type of discourse? What would they be leaving my class with?

INTERVIEWS REVEAL INDIVIDUAL CHANGES

I had interviewed my students in the beginning of the year to help indicate how they approached real-world problems. From

these interviews, I learned about the way they used discourse and how they thought about the relationships between science, school, and themselves. I returned to the same format, problems, and students (see appendices for Chapter 2) to compare how some of my peripheral students as well as the leaders approached scientific problems.

The changes in my students were not limited to how they used patterns of speech or scientific concepts. There were deeper, more significant changes in my students' perception of science in their lives. I noticed three major shifts in students' thinking over the course of instruction: (1) types of scientific explanations, (2) the use of evidence to support warrants, and (3) the view of authority. I noted these shifts in the following table according to the characterization of student scientific reasoning. I included Toulmin's model to examine specific aspects of scientific discourse, and elaborated on each of the before/after characterizations depicted in the boxes below (see Table 5.1).

Table 5.1. Observed Changes in Students' Interview Responses

Scientific Reasoning	**Before**	**After**
What counts as a scientific explanation? *Toulmin: Warrants and answers*	Students offer naive answers. *Warrants are claims or factual answers.*	Students offer more sophisticated answers. *Warrants are testable hypotheses.*
What does it take to answer a scientific question? *Toulmin: Evidence and Backing*	Students are naive observers of the world. *Backing is omitted from observations. Evidence lacks an interpretive framework establishing it's relevance through backing.*	Students are better investigators and observers. *Evidence is linked to warrants through an interpretive framework or backing.*
Who can answer a scientific question? *Toulmin: Authority over answers*	Students perceive others as the experts. *The process of argumentation as acted and imposed upon society by some third party.*	Students develop arguments to support their tentative claims. *Students perceive themselves as having an active role in argumentation as a process that appeals to evidence as a source of authority.*

Before Q: What counts as a scientific explanation?

A: Students offer naive answers.

When students started the year, they thought there was a single correct answer to a scientific problem, and these claims

were fixed, terminal, and non-negotiable. They also thought in naive ways that were characterized by simple, narrow, matter-of-fact answers, which did not conform to Toulmin's model of argumentation. According to Toulmin's model, their assumption of the existence of correct answers to scientific problems challenged using warrants in arguments. Warrants representing tentative reasons believing in a particular idea were absent and facts dominated their responses.

Students' answers reflected singularity and a suggestion of "correct" answers in two different forms: (1) students hesitated and said they did not know the answer, and (2) students gave a definitive answer based upon their own experience. In both cases, students' tendencies for answering the question focused on finding a single solution instead of putting forth a more tentative idea and testing it against evidence.

In the first category were students with no idea where to start the problem I inferred because they thought there was a definite answer to which they were not privy. They appeared to be disabled from further action when faced with a question without a concise answer. Those, from the first category, who responded to this claim made such statements that follow:

Tr He comes to you to ask your advice. What do you tell him?
Erin I have no idea. Sorry.

. . . . .

Tr You need to make recommendations to the principal about what the problem is and what could be done about it. What do you do?
Tasha I don't have a clue. I have no idea. I don't know.

. . . . .

Tr First, you're supposed to tell him what the problem is and the next thing you're supposed to do is tell him about his invention. What would you do and what would you tell him?
Samuel I don't know. I don't know where to start or what to tell ya'. It's hard. I'm stumped.

Several students answered with these types responses. Erin said, "I don't know," more than 10 times during the entrance interviews. These answers exemplified students perceiving there was an answer, but they did not have a way of trying to determine what the answer could be.

I gave two different questions given to each student. Students who answered, "I don't know," to one question, often responded to the other question. There is little reason to think students would act like scientists for one question and like someone else for the other. Students' responses to the other question gave insight to what students thought about the nature of scientific answers.

When students gave answers, they were definitive. These responses were exemplified by the following:

Tr You need to make recommendations to the principal about what the problem is and what could be done about it. What do you do?
Erin There's too much static. Take out the carpet.
Tr How do you now you're right?
Erin Carpet carries static.

. . . . .

Tr He comes to you to asks your advice. What do you tell him?
Kristy There's two different guitars and they're shaped differently. *That's basically how it is.* Different strings go for different things and it's um...You see, when you have a guitar, the strings aren't all the

same length...'cause you see my best friend is a main guitarist for a band....It's like they're stretched out differently and that's why you can't play 'em.

. . . . .

Tr What about his invention?
Kristy Well, he can go ahead and try it and run an experiment on it and everything like that but it's still the size and shape. He's going to have to make it a certain size for that certain string so *no matter what he does it's still going to be the same.* Basically, I've been around guitars for a quite a while and I know the strings and how they are and everything and it is the size of em.

Even though I wrote the problems to allow several possible explanations, students persistently gave answers to questions that were short and definitive; "That's basically how it is" and "...no matter what he does it's still going to be the same." They even fragmented the intentionally complex problems in order to give their answers.

Students did make claims about the world. Whether they new the "correct" answer or not, students assured me there was little room for interpretation or continuing study. In this way warrants were absent from their explanations about the world. This view was consistent with the model of science as it became recognized in traditional classrooms; a view that presents science as fixed set of facts.

After Q: What counts as a scientific explanation?

A: Students offer more sophisticated answers and testable hypotheses.

At the end of the semester, warrants began to appear in students' responses. These warrants took two forms: (1) responses rich with more tentative language. "I might...," "I

think...," "Maybe it's the...," and "Probably..." peppered their discussions, and (2) multiple tests for their tentative ideas were generated. Consider this case with Kristy and Samuel.

Tr How do you advise your friend?
Kristy The string wouldn't work because there's magnets in a guitar and, and the vibrations are sent out by the magnets attracting together and they didn't attract to that certain kind of string because maybe it wasn't a magnetic, device, you know, that attracts magnets. And it wasn't like metal or something or copper or whatever, so it didn't, it wouldn't the magnet couldn't pick it up to send vibrations through the amplifier.
Tr Okay, so you're going to tell him the problem is magnets.
Kristy Um hum.
Tr How are you going to know if you're right, as a scientist?
Kristy *Try it out*, put the...see if, put a magnet by the guitar string and see if it does attract, and then look at the electric guitar and see if there's magnets, and if it is magnets, take them out and put the real guitar string there and try to play it and if it doesn't play, then you know that it has to be one of the main reasons.

. . . . .

Tr How you gonna know you're right?
Samuel Well, I'd have to...do the nylon and, well, what I would do is probably, I don't know, see if electrical waves could go through the metal, and like, hook it up to a battery, and you know, and then, I know it would go through the metal, so, you know, I would prove to him that electric was a conductor and not wood [it] is not a conductor. And then I would show him with the metal, the way it conducts, you know? The way of electricity, so it could go through it. You know?

. . . . .

Samuel The computer may...um...you say, she took it home, and it freezed up?
Tr It was at home for the whole summer, and it acted fine. But in the classroom, it's freezing up and...
Samuel Because, the electricity problem, I think it may have too much electricity current into the computer and it may not be able to handle the currents and may erase the disks, because of too much power. Some things happen like that.

Tr How would too much power erase the disk?
Samuel Are there....I'm not sure about computers, but there may be little magnets in there, that get too powerful for the computer and, you know, magnets erase disks, so maybe the magnets get too powerful and erase all the stuff.
Tr So, you're saying, let me see if I understand this right. A power surge in the plug, going to the computer, and affect the magnetic head making it too strong, then it would erase the disk?
Samuel Right. It's like, there must be too, just too much electrical current flowing through the room or something. I just can't understand why things would stick to the board or....What I would do is, make sure it didn't have any charge at all, you know, like test it somehow and make sure there's, it's neutral, no charge, and then, put it up there and see if it stuck, and if it stuck, I don't know, put a positive charge on it, and see if it like, repels or what happens, and then put a negative charge and see if it'd attract to it, so then they might have a little thing to work with because then I might know what kind of negative or no charge or neutral charge. So, that's what I'd do.

Each student included a reason why they believed in their particular response. However, strikingly, was each also used terms such as "probably" and "maybe," which were not found in their prior responses. In the exit interviews, Samuel, Kristy, and Tasha, alone, included over 30 instances of using more tentative language in their responses.

In addition to students using more tentative approaches to proposing solutions to problems, when I prodded them, they gave explanations and generated multiple tests for their ideas and related tests that generated data relating to their claims. Their tendency to give more than one way to test an idea was different from their original interviews when responses had definitive answers, often without tests or evidence. This aspect of students' responses conformed more with using warrants that Toulmin described.

Below are some tests Kristy, Samuel, and Tasha outlined in their responses:

Kristy	1.	See if the magnets stick to the string.
	2.	Try other types of strings in the electric guitar.
	3.	Look for magnets in the electric guitar and take them out.
	4.	Restring the electric guitar with nylon string without the magnets in it.
Samuel	1.	Get an electrician's black box and look for amount of energy present in the room.
	2.	Hooking the nylon and metal wire up to a battery and showing that only one was a conductor.
	3.	Stand still or scuff your feet and touch the jets.
	4.	Take the disk to another computer and try it
	5.	Charge a folder and stick it to the board
Tasha	1.	Tension? Put strings in tighten them up.
	2.	Metal? Put them both in and test sounds.

These tests in students' responses frequently followed my prompts of, "How do you know you're right?" or "What would you do?" Though these questions were asked in both the entrance and exit interviews, their meanings somehow changed in the students' minds. Students treated the questions in the exit interviews as opportunities to pose a tentative explanation about the problem and include tests to show support for their idea. Moreover, these warrants were discussed in a way to provide multiple forms of evidence to support their warrants.

Before Q: How do students find answers and how is evidence used?

A: Students are naive observers of the world.

When students started the year, they thought scientific evidence were observations that instantly revealed the correct answer without interpretation. Students responded to open-ended questions with certainty that some tests decisively and instantly revealed the "correct" answer. While students gave

answers to the questions, they did not give evidence to support their answer. Therefore, when evidence was given, I could rarely connect it to anything they claimed.

These students' original perceptions of scientific experiments suggested two possible mottoes, "Seeing is believing," or "Evidence can be seen and directly extracted from experiments that 'work'." These notions lacked the aspect of interpretation of evidence or multiple forms of evidence that could be supplied to confirm the validity of an answer. Such responses that support this are:

Tr	So, how would you know if you're right?
Samuel	I'd try 'em both. One worked and one didn't. That's how I'd prove it.
Tr	What if it didn't show you what you expected?
Samuel	Go on and make some more observations.

. . . . .

Tasha	I think he should take the two strings and see if they work together. See why they don't work together. You'd have to play around with the strings for awhile. See why. Maybe it's the thickness of the two strings....See why they work together as well, and see why the others work together but mixing them.
Tr	How do you know if you're right?
Tasha	From everything that's been happening, you could tell from that.

. . . . .

Tr	How do you know that is the problem?
Erin	I'd put the nylon strings in the guitar and see what happens.

. . . . .

Tr	So what would you do?
Erin	There's too much static. Take out the carpet.
Tr	How do you now you're right?"
Erin	Carpet carries static...Well you wouldn't know for sure that it was the carpet. It could be a number of things. Could be the computer something's wrong with it...er... could you read that to me again? (18 seconds pause)

I'm thinking....I guess see if its the carpet or not but I don't know how.

. . . . .

Tr How are you going to know who you're right?
Kristy 'Cause you could test it out in tons of guitars of different sizes and shapes.
(Kristy never did explain what IT was.)
Kristy I could try mine out and they could test theirs out.
Tr And how do you know who's right?
Kristy Compare them together. See which one works and which one doesn't.

For each response there was never a clear indication of what people were to do or look for in the experiment. Verbs without clarifiers such as "See," "Do," or "Test" were left open without clarifying what "it" was that would be seen or revealed. Responses often left the astute scientific reader with the feeling they read unfinished sentences. What was "it" the interviewer would see?

Such responses supported the position students were not familiar with scientists' common activities such as designing tests and using evidence to confirm beliefs. Scientists used a consistent theoretical framework in which they made sense of their data; a more sophisticated understanding of science regarded experiments as revealing selective information. The sophistication of the experiment and the preciseness of the explanation of the experiment design measured students' understanding of the subject matter and the process. In these examples, answers suggested limited knowledge of the subject matter and the nature of science.

After **Q: How do students find answers and how is evidence used?**

A: Students are better investigators and observers. Evidence is used with an interpretive framework.

After the semester, students offered more direction to me, their interviewer, about their tests. By directing me towards the specific relevance to the warrant, the students provided a backing to their argument. They had a specific purpose for including particular aspects of their evidence and they chose them with some notion of why these aspects would support their ideas.

This was more consistent with the way scientific experts designed and observed experiments. Before carrying out experiments, experts' tests clarified what was to be done and what was to be observed. They did not set up experiments and write down absolutely everything that took place. As an interviewer, I realized following students' design and instructions for tests were far easier to follow than the

initial interview responses. Sometimes they were even more concise than tests I had envisioned.

Tr What things would you look at?
Karlton How the strings are made you now? If they're coils or, you know how they're made...I'd tell him I wasn't sure why, but I would just...it wouldn't work.
I'd try, tell him to try, to yank the carpeting, and see if it works. And if that doesn't solve it, then check other possibilities.

. . . . .

Karlton I'd try different types of strings on acoustic and electric guitars an like the larger strings on the acoustic are like metal, I'd try those on an electrical, and see if it's a diff...totally different type of string or what.

Tr And what would that tell you?
Karlton It'd tell you if it was possible.

. . . . .

Erin Well, if you wanted to figure out if you can possible make a plas...a plastic string for, what would conduct electricity, you'd have to try to find a plastic first, that would do that, and that means you would have to find a...would a magnet work? Maybe. I don't know, maybe the magnet would attract to a certain plastic that could conduct electricity cause there's metal in it.

. . . . .

Samuel Well I'd have to ...do the nylon and , well, what I would do is probably, I don't know, see if electrical waves could go through the metal and like hook it up to the battery, and you now, and then, I know if it would go through the metal, so you know I would prove to him that electric was a conductor and not nylon is not a conductor....
Tr What else could you do?
Samuel I'd plug it in, and play it, and then unplug it and show him. I thin that I could convince him that I was right. By doing that...If he didn't then I'd have to try some other ways.
Tr Are there other tests you could do?
Samuel I don't know. I'd have to think of some.

. . . . .

Tr So what do you tell the principal?
Samuel Not to use the room.
Tr Is there a way to fix the problem?
Samuel Yeah, I mean, there's always a way to fix it, it's just the problem of finding out exactly what the problem is. I don't necessarily think that I'd be able to figure it out, I just think that...I may be able to have some conclusions or questions that may help figure it out. But I think that, you'd have to have, like, you know, people who know about wiring and stuff like that, like electricity just to come in with their special equipment and see exactly where the strong points of the electricity are and...go from there.

Tr Okay. Could you run any of those tests?

Samuel Sure. I'd try it. I mean, if I knew how to use the equipment, and, I could run some of those tests. I'd use a magnet to see, I mean, it sticks to paper, so, I'd put a magnet up there and see if that worked, and if that, if that stuck to the wall, then there's something really wrong. I don't know exactly what. I don't know what else I would do.

. . . . .

Samuel I just can't understand why things would stick to the board or...What I would do is, make sure it didn't have any charge at all, you know, like test it somehow and make sure there's, it's neutral, no charge, and then, put it up there and see if it stuck, and if it stuck, I don't know, put a positive charge on it, and see if it like, repels or what happens, and then put a negative charge and see if it'd attract to it, so then they might have a little thing to work with because then I might know what kind of negative or no charge or neutral charge. So, that's what I'd do.

In these examples students specified the evidence they would look for in their experiments. Often these responses were characterized by, "If this... then this... so..." In their exit interviews there were few instances that proposed tests were not directly followed with instructions of what to look for or what relevance their experiment was to the question. In Karlton, Samuel, and Erin's interviews there were more than 15 instances of these If-Then phrases. Moreover, students showed evidence of including subject matter knowledge from their classroom experiments to solve the problem. Not Surprisingly, students mentioned specific experiments with tuning forks, magnets, and electronic and static equipment in describing what evidence they would look for. These events were used in a process of argumentation that was significantly different. Their knowledge has become an active part of making sense and decisions about the world.

Before Q: Who can answer a scientific question?

A: Students perceive authority outside of their grasp.

Students began the year believing authority over answers lies in a third party; someone else could solve their problem or could give a better response. Therefore, their response was less valid in some ways than a third party. Some responses that supported this claim were,

Erin I'd tell 'em to go to a music store. THEY know a lot about strings there. I think THEY have those kinds of strings. Don't THEY?

. . . . .

Erin I'd call in some electricians to check the wiring and to (HAVE THEM) run some tests.

. . . . .

Tr Do you think it would work?
Tasha It depends on everything HE's experimented with. If it works good. If it doesn't, maybe HE could test something else. Maybe even get someone ELSE's opinion about it.
Tr That's why he came to you.
Tasha Besides me.
Tr What else could you do?
Tasha You could have someone come in and [HAVE THEM] look at it.

. . . . .

Tr And if that didn't show what you wanted?
Samuel I'd rub my feet on the floor and touch the computer. I'd have to do something else. I don't know what though. I'd show someone else, maybe an electrician, what I had done so HE could figure it out.

Kristy presented an interesting twist to this claim. Instead of defaulting to evidence or another authority, Kristy supported her answer with a personal claim as an expert. When I asked her how she would know she's right, she became more assertive in her answer.

Tr How will you know? What if someone disagrees with you?

Kristy You could try it out on tons of guitars and test it out. But that I've been around guitars for a long time and I'm sure that I'm right.

. . . . .

Kristy (concerning the electrical problem) You could try the other guy's idea of a short in the wall but you'd want to try mine first because it's easier and I'm sure I'm right.

To add more power to her claim she introduced herself as the expert by introducing first person "I" talk and inserting more assertive statements like "I'm sure," or "I'm certain." This also suggested a naive view of scientific argumentation as deferring to someone else. From these examples, being right had more to do with a personal significance of who you are rather than the body of evidence. Neither Kristy's nor other students' approach conforms to how scientists solve problems. As AAAS described scientific authority,

> In the long run, no scientist however famous or highly placed, is empowered to decide for other scientists what is true, for none are believed by other scientists to have special access to the truth. (AAAS, pp. 28-29)

After Q: Who can answer a scientific question?

A: Students perceive themselves as having an active role in argumentation as a process that appeals to evidence as a source of authority.

Students were now apt to turn the authority over correct answers to the body of evidence. When asked how they would know

if they were right, they all referred to the body of evidence their tests would produce. In essence there was an added dimension of inference to data that was not present in entrance interviews. The message was, "Evidence will show who's right and this is what to look for."

Tr "How will you know if you're right?"
Kristy Try it out, see if...put a magnet by the guitar sting and see if it does attract, and then, electric guitar and magnets and see if it is magnets, take them out and put the real guitar string there and try to play it and if it doesn't play, then you know that it has to be one of the main reasons.
Tr What if someone said, "No, that's not the answer?"
Kristy Then they'd gave to go test out what they think. I mean, if I have...if I had an experiment and a reason and I test it out and if they're going to disagree with me, then they're going to have to experiment and test theirs own out see if it comes out right.

. . . . .

Karlton Invent an experiment or something for him...How the strings are made, you know? If they're coils or you know how they're made....I'd try different types of strings on acoustic and electric guitars an like the larder strings on the acoustic are like metal, I'd try tons on an electrical, and see if it's a diff...totally different type of string or what.
Tr Anything else you'd look for?
Karlton The frequency of the vibration. Like we did with those...fork things. Like...when you tighten the string and it vibrates different, and see if you could use, like the smallest metal string on the acoustic and tighten it really tight to make it work for the electric guitar just like that.

. . . . .

Samuel Well I'd have to ...do the nylon and , well, what I would do is probably, I don't know, see if electrical waves could go through the metal and like hook it up to the battery, and you now, and then, I know if it would go through the metal, so you know I would prove to him that electric was a conductor and not nylon is not a conductor....I thin I could convince him that I was right. By doing that...If he didn't then I'd have to try some other ways.
Tr Are there other tests you cold do?
Samuel I don't know. I'd have to think of some.

As I noted in the earlier results, students became more active in generating experiments and using knowledge to make decisions about real world problems. They showed evidence of becoming a part of as opposed to being subject to the process. Even though students were occasionally detained because they could not think of other experiments to run, they knew more could be done and perhaps they would be the ones to solve the problem.

Evidently, this locus of control over answers shifted. Samuel's example was the clearest. Samuel described an electrician being called in to help with the problem in both entrance and exit interviews. In both interviews, his electrician was an expert in some electrical capacity. The difference in using this person was the key support for this claim. In the entrance interview Samuel called in the electrician if his experiment did not work then, "[The electrician] would figure it out." In the exit interview, Samuel mentioned a black box electricians used to sense energy surges and he would ask the electrician to look for the amount of power in the wires. Samuel shifted the role of the expert from one with the answer to one who could provide important information to answer the question. When asked if he could perform some of the electrician's test, Samuel responded he needed simply to understand how to operate the devices. Then Samuel felt he could solve the problem.

DISCUSSION

My general statement about my students was that there was major shifts in their acquisition of scientific discourse in

open discussions and in private reflection. Although my students did not reinvent the exact explanation scientists agree upon today, their approximations and ways of knowing their answer was a supportable one was a testament to their expertise. I point to their daily efforts to examine, invent, evaluate, and refine their beliefs as participants in the process of making sense, not as the replication or proof of precisely defined concepts practicing scientists use in their work.

There was a marked shift in the notion of how one becomes an expert. My students entered thinking experts have "correct" answers and these answers were fixed and final. They exited, however, with a different understanding of what it meant to be an expert. Practices like generating models and explanations, designing experiments to produce relevant data to test those explanations, and arguing about the interpretation of gathered evidence had taught my students they too were experts in some ways. They were no longer bound to texts or teachers for final answers. They gained some authority over scientific answers and, in Samuel's words, could "think of some tests" if they were posed with a problem to be solved.

I engaged them in a social process of refining one's position in the context of competing tentative notions about the world. Together they produced an explanation of a complicated phenomenon that could only be supported by indirect evidence and the invention of an abstract model of unseen forces. They had a good grasp of electromagnetic attraction that had a foundation in their daily lives and experience.

More importantly, this social process was one they internalized. The practice of confronting inadequate ideas with discrediting evidence impacted their private thoughts about the world. As a result, my students learned to be their own judge over the appropriateness of their answers. They learned to sustain a tentative idea and withhold final judgment until there was enough evidence to refute or substantiate the idea. Further, they learned to do this in their private thoughts without peer support. They developed the ability to carry on a social process of simultaneously promoting and critiquing knowledge within their own minds, exercising both sides of debate while constructing an acceptable conception of the world.

My students changed the ways they engaged in scientific arguments. However, this change meant more than acquiring a discourse and thinking differently about the world and the objects we studied. Through this discourse, they also thought differently about their place in the world. In some ways, my students were empowered.

My students still carried many social scars that were less than redeeming. They argued using evidence, but not without social losses and victories; many still treated one another in ways that abused and demeaned others for their own personal status. Whether these discourse patterns are inherent in the nature of schooling, or in interactions between alienated students, or in the process of competing collectively for the dominance of a single scientific explanation, my students were not beyond insulting one another in disagreements. There were

those students who were shut-down, ridiculed, and thought less of for their ideas. I wondered about the students who did not make it through the first semester and asked myself whether the discourse I promoted was too foreign or whether my efforts promoting this discourse alienated them further. I will never know.

Regardless of the reasons for their dropping out or for the general failures of discourse in my class, my classroom was less than the cooperative setting I had imagined. Why did I think it would not be? Was my understanding of the scientific discipline one of a cooperative commune of polite disagreements? Many of my scientist friends laughed at this notion and my own personal experience refuted this pious representation as well. How did I concoct such a vision for my classroom?

I realized my dream for a science class was not based upon what a scientific community really looks like. I experienced first hand the chemistry laboratory and the cut-throat competition that occurred in this R&D setting. My experience was not with generous polite scientists, but with ones who stole, lied, threatened, or cheated to advance themselves. How could have I sensibly thought students would act civilly just because they were doing science? I asked students to act like a scientific community, but at the same time demanded they did not, and asked them to act like a community of people I never knew and some researchers (Traweek, 1988; and Latour and Woolgar, 1986) argued never existed.

I came to grips with the facts scientists are human too and I tried to create something that does not exist. It was not that I did not have good reason to demand they justify their claims with evidence and simultaneously treat one another civilly, it was that this vision was motivated by two separate strands of my thinking that, somehow as a science teacher, I united. I always thought people should be treated with respect and be polite, and held this belief long before ever figuring out what exactly I thought it meant for students to act scientifically. This teaching experience, brought questions to my mind of why I thought both competition and courtesy could occur in the same classroom.

I clearly knew what I expected of students, but was not clear about why. I did not ask students to be civil because that was what scientists did; I asked them to treat one another better because that was what I thought was correct, regardless what scientists did. Most scientists are grown-ups who know better, but I am charged with creating citizens that would make better choices than they. As a result, knowing what I know now, I left with larger questions of the feasibility of creating such an environment.

CHAPTER 6

OVERVIEW.....239

CHANGES IN CLASSROOM DISCOURSE.....240

Students Changed.....240

Aspects of Discourse That Changed.....242

Aspects of Discourse That Changed Little.....244

ISSUES THAT STILL NEED BETTER UNDERSTANDING.....246

The Desirability of Scientific Discourse.....246

Teachers and Students Learning to Act, Speak, and ....

Think Differently.....248

Analyzing and Understanding Changing Classrooms.....251

IMPLICATIONS FOR REFORMING SCHOOLS AND SCIENCE CLASSROOM...256

Balancing Issues and Reality.....256

Critical Barriers to Change.....259

Rethinking Effects of Tracking Students.....262

Struggles and Resistance.....262

Acquiring Instead of Learning Scientific Discourse....263

IMPLICATIONS FOR RESEARCH.....264

Studying What Happens to All Science Students.....264

Rethinking Central Issues of Science Education.....266

Finding New Ways to Discuss Scientific Literacy.....266

CHAPTER 6

Where I Ended Up

OVERVIEW

Through the course of the year, my analysis revealed there were many significant changes in my students; some of these changes were desirable and others were not. However, overall, my class developed into a new community that operated differently. In chapter 6, I reflect on the lessons I and my students learned after designing a science classroom community following current reform recommendations. I begin by highlighting intended changes in my students' abilities to formulate arguments, and note their changes and abilities to assimilate a scientific community, and other changes and observations that suggest I ultimately did not transform my class into the community reformers would hold up as exemplary. Next, I point to certain issues inherent in invoking such changes toward a scientific discourse--issues that challenge inherent school agendas, and present the assumptions of the nature of change in schools or discourse communities. Finally, I discuss some implications of my findings to guide others' attempts at venturing off the beaten track of traditional science teaching toward establishing a community of scientific learners.

CHANGES IN CLASSROOM DISCOURSE

Students Changed

My students learned to speak and sustain discourse about scientific problems differently. After they realized I did not simply give correct answers to their scientific questions, they searched for definitive, factual, scientific answers to world problems and began asking their own questions with a tentative answers. Subsequently, as they learned to develop arguments and explanations for their observations, they learned ways to determine the best answer as a group. These arguments differed from their original discourse that predominated their individual and collective work.

Interview and classroom participation discourses revealed when students created arguments or decided on alternative explanations for real world events, they deferred to evidence as the authority. When I asked questions dealing with how they would test what they thought or knew, they created cases that intricately linked what they believed to available evidence. As the interviews revealed, students approached world problems differently and applied what they learned about developing scientific arguments. As a result, their intellectual products were more meaningful and useful to them than the factual information they had brought with them to their first interviews.

My students became proficient at interpreting and synthesizing evidence to support their beliefs, and more expert in producing evidence. Their interviews and some classroom

discussions revealed their ability to design relevant experiments--experiments guided by the inferences connecting what they knew to what they wanted to discover. They developed tests and, sometimes, spontaneously developed experiments revealing a rich understanding of difficult scientific ideas such as electromagnetic induction.

Collectively, my students acted, thought, and spoke differently as well. They developed ways of disagreeing that were more productive, efficient, and fruitful. Class discussions hinged on informing the group and evaluating available evidence, convincing others of the veracity of their interpretation, and finding ways to produce more evidence to resolve arguments when there was an insurmountable difference of opinion. Sometimes this would entail designing new experiments.

Early in the year, some students increased the tension and decreased the progress of discussions by attacking some personal attribute of the speaker or claiming some personal exclusive expertise such as, "I just KNOW it" or "My uncle is a firefighter and he told me...." Later in the year, however, students did not allow their peers to participate in these ways; evidence played a primary part in developing an authority over answers. If students disagreed, claims of expertise were not left at a personal level, for example, Dimitri announced, "I KNOW she's wrong," his peers demanded, "HOW do you know?" These and other questions drove the class to collectively weed out the opinions from the founded ideas of the class. Students drove

substantiating ideas beyond personal claims of expertise that once ended arguments in stalemate.

The continual pruning and evaluating of ideas became a part of class discussion my students sustained. Controversy and debate over tentative ideas were not simply situations they read about in some annals of scientific history. They actively engaged in the push and pull of ideas--ideas they developed with sophistication, accuracy, and detail.

These were the ways my students became more expert in using scientific discourse. This tentative treatment of knowledge they acquired was more expertise than learning the long lists of scientific concepts that scientists knew. Though their accomplishments did not read as a table of contents of topics that were learned, they were ways my students accomplished the curriculum I promoted. Also, these accomplishments were ways scientists interacted that were consistent with what I understood science to be, and reform recommendations echoed what science education to be.

Aspects of Discourse That Changed

Once I established some instances I interpreted as meaningful and productive scientific arguments about students' ideas, I was bothered by the presence of aggressive and competitive norms--norms leading students to criticize one another and not just the ideas they discussed. As a regular part of disagreements, students interrupted one another, demeaned their peers for their beliefs, and made personal attacks on one another; they were abrasive and insensitive

towards one another. Attempting to prove their side, discredit competitors, or simply silence opposition, my students resorted to rude behaviors. As a result, this competitiveness of ideas the community promoted blossomed, at times, into competitiveness among members of the community.

Competition was not new to our community, nor did promoting fundamental science change the way my students felt they should treat one another. Social status was as important to them as it was when they entered the class, so was winning. Certain individuals preserved their status by using this newly acquired discourse to discredit their adversaries. Public disagreement was used to engage adversaries in social battles with real losses, for example, when Dimitri silenced his opponents, others would laugh or cheer. As a result, other members chose not to engage in such arguments because of the social risks involved. As Cindey described, the discourse of arguing scientifically led her to "feel like I'm nothin'." In some ways, this putting others down and criticizing peers was understood to be necessary to advance the group. Whereas before, students insulted one another for personal reasons; insults were a way to quickly get to the heart of the disagreement and throw away less useful ideas. I encouraged them to disagree and listen critically to one another and, to some degree, condoned and promoted this behavior, which is a large part of scientists' activity.

Students intentionally excluded or shunned certain community members because of their beliefs or factions. Some withdrawn students at the beginning of the year, continued to

rarely participate in the midst of these public exchanges of ideas. Usually male students, aggressive when challenged, dominated arguments about evidence. But, overall, the students primarily driving class discussions and maintaining influence over their peers already had many social and intellectual skills.

There were many events--events requiring me to intercede on behalf of my students' safety--when they nearly brawled. These students were reprimanded in ways according to their intellectual or scientific work. But these behaviors did not bother them as much as they bothered me; as far as my students were concerned, these behaviors were simply a part of how things were accomplished. While I was concerned with correcting injustices, and explaining how and why they were reprimanded, they responded by erupting and then getting over it; "Let's go on," they announced, or "It's getting old." Though their emotional engagement revealed the genuineness of their work, I was uncomfortable with their treatment of one another.

Social status continued to be an important prize with students and they were not bashful in their strife to achieve a higher status. At times, scientific arguments became another way in which existing social struggles were played out with different rules. Scientific arguments simply replaced other ways they competed.

Aspects of Discourse That Changed Little

Though there were changes in my classroom discourse, there was evidence that the rest of the school life, and life outside

school, remained relatively unchanged, and for some reason, I was unable to change their feelings about school. Because, my students were lower track for quite some time, they learned to respond to school in certain recognizable patterns. They challenged school authority, pushed the limits of my expectations, resisted my efforts to teaching, created instances putting us at odds with one another, and resisted and sought compromises of what I asked of them.

I expected my students would try achieving what I laid out for them, anticipated the problems I would run into were about breakdowns in arguments for different reasons, and presumed, as reforms presumed, my students would automatically engage in what I asked them to do simply because this activity was better than what they knew, or simply because I asked them. However, what ensued was different from my expectations. Instead, discourse broke down as a result of my students' resistance; they did not engage as I asked them. In fact, in some ways, their history of disengagement and alienation made them less prone to do the things I asked because I was the one asking.

They were hostile, not only toward one another, but toward school policy and authority. Brent's incident carried many indications of how my class, as a whole, sought to be separated and removed from school's control or influence. Because, they were still at odds with the school in many ways, and I was still an agent of the school, they communicated to me that I was not able to completely change the way they spoke, thought, and acted in the class. Wrongly, I presumed, if necessary changes were

made through instruction, then students would automatically engage. Though this is the picture painted by current reforms, this was not true for all students. My students acted in ways counter to my goals and I could not have anticipated these from adopting the current vision of science education reform, even though there were good explanations offered from other research perspectives that explained my observations.

Overall, even though my students progressed positively, my classroom still was not the scientific community I or reforms envisioned. Classrooms were different places than scientific labs with different agendas and individuals consisting of different histories. As a result, my class was more scientific, but definitely not a utopia.

ISSUES THAT STILL NEED BETTER UNDERSTANDING

The Desirability of Scientific Discourse

My students' discourse did change over the course of my study in ways I interpreted as scientific, but with these changes came perplexing questions about the benefits to my students, the nature of the work involved in changing the discourse community, and the influence of the school context on these changes. Some discourse changes I observed were not acceptable with the charge of socializing students in a democratic, cooperative manner. In fact, in retrospect, many students reasonably acted contrary to such ideals.

My students' aggressive and competitive behaviors were not foreign to my experience in the research lab. In fact, these behaviors were consistent with many other insiders'

interpretations (Traweek, 1988; Latour and Wolgar, 1986; and Lemke, 1990). The portrayal of scientific communities that paint a picture of members promoting only pristine, cleaned-up versions of rational arguments leading to logical conclusions and socially accepted concepts does not actually describe how much work actually is accomplished. Intellectual struggles can be sloppy and face-to-face, and competition in the scientific community does get ugly. Scientists like winning and sometimes plan strategies against their foes with reckless abandon, similar to my students.

These aggressive behaviors were not consistent or condoned by reform recommendations because the picture reforms paint is one of collaborative, cooperative work. There is no indication of a need to keep children from hurting one another during intellectual conflict. Yet, this was one of the outcomes of getting my students to publicly disagree. My attempts to change the discourse put me at odds with other school agendas such as developing collaborative work with others and respecting all community members. Such behaviors may be indigenous to scientific collective work, but are not condoned in schools promoting more democratic ideals. Educators cannot instruct our students to act as adults in this community because we hold higher ideals for our children than emulating the negative behavior of adults who know better.

I continue to ask myself questions about who benefited from such a shift in discourse and what parts of scientific arguments simply "come with the territory." Did it really help my

students to participate in a discourse community similar to this one? Can only parts of a discourse be acquired while other parts left behind? I know scientists argue and compete for status, but I am troubled with having promoted this in my students. I am not sure what aspects of scientific, collective activity can be extracted or adapted to an environment charged with socializing students with more democratic ideals. Because scientific communities operate under different assumptions and rules, perhaps getting students to act like scientists may not be exactly what educators want to do.

Teachers and Students Learning to Act, Speak, and Think Differently

I was unprepared to face the obstacles I report in this study. Even though I read the reforms and designed my study, unfortunately, I did not give enough thought to issues such as my students' alienation or how to make scientific discourse more accessible to my students. Naively, I presumed I could model appropriate patterns to approach problems, to discuss evidence, and to remove myself as the final authority over answers, while facilitating class discussion forcing students to draw their own conclusions.

However, change was not this easy. Changing the classroom discourse was not a matter of simply replacing what did not work with something that would. We had to relearn and re-negotiate the rules of participation and I had to learn to listen carefully to the way my students talked with one another to recognize inappropriate behavior. So, together we struggled to find ways to participate appropriately as members of a new

community. On the one side, while my students lobbied for the opportunity to give single word answers approved by the teacher, I refused to respond in those ways. Now, they learned to pose tentative warrants, construct arguments using evidence, evaluate their own ideas, and learn how to respond when I asked them, "Why do you think that happens?" or "What makes you think his explanation is wrong?"

On the other hand, I tried teaching them how to disagree with one another productively, but I also had to be sensitive when their scientific dialogue was about to break down or when they made insults. I learned to be a part of their conversations, to sense when things were tense, to recognize personal attacks, and to defuse a dangerous situation.

Steele (1992), who was helpful in helping my think about increasing student engagement, was right; no matter how difficult the situation, finding value in what students brought to class was important because this would make engagement easier for the teacher and them. With this knowledge of my students, I tried to motivate, understand, control my students, and even shape their social knowledge as well as scientific knowledge.

At the outset, we had little knowledge of what appropriate participation was, but, through successive approximations, we re-negotiated the classroom participation. Changing classroom discourse required making fully informed judgments and taking actions. For example, I tried recognizing when they asked sincere questions about the world we could answer as a class, but as a result, our lessons were often learned through negative

examples. Because, in a number of instances, I falsely sensed students were on the verge of a fist-to-cuffs and interceded as my students responded, "Don't worry about it." In another instance my students interpreted the freedom to express their beliefs as giving them permission to talk about anything they wanted or desired. As a result in both uncomfortable and difficult situations, there was a better understanding of what constituted appropriate participation. Many times, we made wrong judgments and learned to participate in new ways.

Trial and error may be the only way to acquire a secondary discourse like that I was promoting, but having figured that out is of little consolation because it was so hard to pull off. Even though in chapters 3, 4, and 5, in which I present my data, there were only three key events and time frames, these examples represented more. They marked the changes throughout this process that were arduous, nonlinear, and often painful. (Most lessons I learned about how to establish this type of discourse was highly specific to the type of student population, teacher, community, and even the given day.) Facilitating this type of secondary, scientific discourse required considerable knowledge of students, schools, and subject matter that was difficult to transfer, or even explicate for that matter, from one situation to the next. So, I am left to wonder what knowledge is required to accomplish this ultimate outcome and how do educators acquire this type of knowledge?

My problems went beyond the understanding my students' discourse and the way science fitted into their lives; I made

certain Rouseauian assumptions about my students from buying into the ideal portrayal of reform language promoting that students would be free to explore their own ideas uninhibited. These naive assumptions led me into at least two avoidable, painful situations--when I told them we would talk about science and not parties, and when I corrected them for abusing one another. Whether or not scientific communities actually control their members, clearly I had to. Still, educators need to understand the difference between the agendas of scientific and school communities and how they can work together. Future science education research should better explicate what is reasonable to expect while changing the nature of science instruction.

Analyzing and Understanding Changing Classrooms

Quickly, I learned the theoretical framework with which I began this study was inadequate either to guide my practices or to analyze what was happening in my classroom. This study provided me with many opportunities for intellectual growth, but I am still concerned about the adequacy of the conceptual framework we use to analyze science classrooms.

In designing my study, I anticipated students would make decisions about scientific problems in the classroom for two reasons--they would either believe me, or they would defer to evidence or personal beliefs. I decided to withhold answers and therefore, by design, learn about how they made decisions. This seemed consistent with the way science educators viewed the problem of having students develop arguments about the world.

Though we might focus on evidence and arguments for changing students' minds, I know what really compels them to change their minds has not been established.

While my students listened to others and weighed the merits of evidence on competing theories, there was a case to be made for Dimitri and others having social influence over their classmates. Even with my present way of looking at science classrooms, I cannot be certain exactly why students changed their minds or accepted certain explanations, and under what conditions students would use evidence or backing more than social influence. What other factors influence how students argue, make decisions, or even decide how to participate in classrooms? To answer this question I need to study and learn more about how group norms are established, acquired, or re-negotiated. My methods resulted in changes, but did not reveal the causes. What led to such changes and what was the progression or development of situations that made the difference? How do educators go about studying why students engage in science problems and in classrooms the way they do? Particularly, with regard to alienation, how do their views of themselves, teachers, and schools influence the way they construct a consistent or evolving approach to class participation?

My compiled research questions and gathered data focused mostly on what occurred within my classroom, but well into my study, I realized this focus was often inadequate because a significant portion of my students' discourse focused on outside

issues. Although my thinking about my students evolved when I reviewed my data, I only found clips and discontinuous indicators that supported alienation was present. I did not intend on examining my students' alienation. So, the tools and data I initially used needed to be revised to capture the essence of our struggles. Even then I still make inferences about student alienation that would require a host of data about my student social lives that I was not able to tap. I have little information available to make claims about whether factors influencing their alienation changed during the school year. What role did social factors play in changing my students' discourse?

My students' strong histories of failure, home discourse, and outside classroom issues tainted their school experience. To better understand this, I would have had to inform my data gathering with other voices and analysis tools. Asking the students where they fell in the school context was a question I should have asked on the first day, but did not because I was interested in the way they argued. Their answers would have allowed me to make claims about where they saw themselves and how my class fitted into their beliefs about school. In restructuring my study, I would have to be include how they talked about science and the world with their parents, friends, and others. Even though I tried assessing how they talked about the world differently, I did not gather evidence outside the class to suggest there was any change or to understand what other roots to their discourse could have influenced their

participation, understanding, or identity. If the family and other defined sets of intimate circles are where primary discourses are learned, then educators need to observe and analyze these places for discourse patterns, not just the classroom or one-on-one interviews.

Another avenue to pursue in understanding my students' alienation includes investigating that their actions may significantly change within specific peer groups. If groups of students do agree upon accepted ways of interacting within the group that are determined by how well they are rewarded for acting defiantly, then how do they comprehend the events they find themselves in with different peers? How do they make sense of their position in school when they are involved with different peers? Before, making broad claims on how they thought about "school," I needed to know more about how they acted individually in other classes to know about how they viewed themselves as a collective in my class and why their individual identity changed when they were with me. I heard they sometimes did do well in other classes. So, why do norms shift when they are together? As a result of gathering and analyzing answers to these questions, I would then know more about how my students felt about themselves and science as well as their position in school. In addition, there are other ways to analyze students' responses and actions with regard to their separation, alienation, and resistance to school. But, I would need to learn more about how to get more tools to interpret student responses and events I could have included early on in

my study concerning assessing and responding to their social backgrounds.

Also, I would like to learn how accepted classroom norms get re-negotiated. Evidently, what we--I and students--ended up with as a community resembled little what either of us planned. Somehow, we negotiated a reasonable compromise with which we could function with while still evolving and influencing the compromise. I think educators need to develop research tools and thinking frameworks about how to examine and study communities undergoing change. I still question the acquisition process; why does the process seem to take unexpected turns as people engage in trying an identity with which they are unfamiliar? Especially in the classroom situation, where only one community member has some idea of the direction he/she would like to take the other members, how are expectations, values, norms, and other related discourse characteristics renegotiated? Within these research tools and thinking frameworks about classroom cultures, there may be an answer to the larger question of how educators go about changing deeply rooted beliefs students have about school.

Overall, my research taught me my observations were steered and skewed by what I already believed about students. I did not anticipate that much of what we would deal with from the onset was a difference in interpretation of what I felt school had to do with their lives and what they thought. Examining primary discourse, students' participation roles in multiple settings, and norms getting re-negotiated in the class context are still

undeveloped ideas that lie outside the norm or common language to understand teaching or learning. Because of my several sets of surprises I did not consider before designing my study, I think the science education discipline ought to consider the ways in which current portrayals and spelled out issues really capture what educators want to know or understand about science classrooms because my evidence reveals resistance and alienation will jade their events, especially if they are not parts of the research design to study lower track students in science classrooms.

IMPLICATIONS FOR REFORMING SCHOOLS AND SCIENCE CLASSROOM

Balancing Issues and Reality

I entered my classroom in Farmersville with a set of ideals to use in establishing and working within the classroom. In fact, much of my teaching was shaped, or at least informed, by some ideal model of how scientific communities operated, but my resulting operating community and its products looked very little like this ideal. I do not attribute the problems I encountered to any specific arena of informing the teacher practice, i.e. bad teaching or unprepared students, but instead to a clash of idealism and reality. Now, in view of an ideal scientific community spelled out by AAAS 2061 and other idealistic portrayals of scientific activity and communities, I ponder to what degree was it useful for me to think about my class.

There are two possible extremes for the vision of science education reform--neither of which I would argue as useful. One

is the idealistic way scientific communities operate that is spelled out by AAAS 2061 and others. This cooperative, rational, pristine portrayal of the scientific community ignores major observations about human behavior in communities; this portrayal talks about human institutions and communities that essentially omits aspects of human interaction that are real in any arena.

Adopting this perspective and ideal through which to view the interactions and products of my classroom left me discouraged and confused. I was ill-prepared for the pedagogical and methodological questions associated with invoking change in real classrooms. By presuming I could get my students to argue, discuss, and inquire free of selfish motivation, I set myself up to encounter major obstacles in my teaching. I did not plan or know how to interpret the problems associated with antagonism, status, and competition that my pedagogical choices instigated. In addition, this perspective impaired my research in that I was blind-sided by events I was unprepared to analyze or research. I did not know how to view my students' arguments and how to determine whether they were really acting "scientifically." People do not operate like this. So, if educators adopt this way, then, inevitably, individuals seeking to produce such a situation will be highly disappointed and unprepared for what they will face.

On the other hand, educators could adopt another vision for science education that strictly adheres to the insiders' perspective. I found that these other, ethnographic portrayals

of science would have been helpful to predict and explain the events I encountered and how scientific work looked in my classroom. Had I considered Traweek, Latour and Wolgar as a model for science, I could have prepared for the types of competitive and antagonistic norms I encountered while getting smaller groups to disagree in a semi-cooperative setting.

But this vision is difficult to hold as an idea for how educators would model their classrooms. Also, this vision has problems; educators will perpetuate values and norms that do not fit well with other school agendas and visions they possess. While Dimitri promoted an idea that explained more evidence, the promotion process was at the expense of others in the group. New problems are associated with the teachers' role requiring them to take action that scientific community members would presume as a whole. As the teacher in the class, I was responsible for protecting all students' interests and for insuring a safe and fair environment for all students to participate. It is difficult to find an analogy for this monolithic authority figure or action in the scientific community because this charge is somehow absorbed into the members' functional role in the community. The difficulty is not that the competition does not exist or that selfish ambition does not drive many scientific discussions or products, but rather this community of members, somehow, has other ways to monitor and guide such characteristics into more productive efforts that make the community a long time established institution in the real world.

So what do educators shoot for? Regardless of how they choose their vision, they should choose from somewhere between the two extremes of how ideally they desire them to be and how real people with ill-intentions drive them to be. Somehow the vision for science education should include that people, by nature, can be hurtful, selfish, and competitive. Plans for making schools and the world better must somehow recognize the continued existence of selfishness and competitiveness in children and adults. It is important to recognize that while schools are one place to teach these characteristics, communities have other ways to monitor and guide the funneling of such characteristics that make them lasting institutions.

Critical Barriers to Change

I attribute many of my struggles to working against some critical barriers inherent in modeling the classroom after a scientific discourse community. One of the first barriers I encountered was how my students came to understand school. My students learned to perform and navigate their ways in class with traditional discourse patterns that were counterproductive. While I tried to create instances to use evidence to solve arguments, my students looked for closure on subject matter discussions. They avoided sustained debate about ideas and this avoidance was complicated further because they tended to place me in the position of solving disagreements with some expert decree. I resisted and tried to redirect discussions, but, unfortunately, the way they expected me to act and speak strongly influenced the class products.

Normal classroom discourse and thoughts, words, actions, and intentions that drive the discourse kept us, in some ways, from assimilating a scientific community. All agendas the participants use to make sense of how to operate within their community produce this discourse. As a result, discourse is neither easy to change nor simply extracted or moved aside. Members skew the identity of the collective, and this identity is reflected in the community's products. I need to further explicate the important differences between these two types of communities--school and scientific--, before I understand exactly why I was so challenged. I hold reservations about the feasibility of replacing classroom discourse with purely scientific discourse as I had once envisioned. I still question whether or not attempting to change students' discourse to reflect the scientific discourse is possible or even desirable.

The most critical barrier is related to students' identity, engagement, and alienation. School was a place where my students disliked, resisted, and scoffed, and yet, they were compelled to attend. There were ways my students communicated to me their disinterest and skepticism. For example, at times, because they wanted to, we made little progress. Often, even though they were aware of the consequences of defiance, they clearly showed their resistance by praising individuals' defiant efforts. In short, they were not simply victims or recipients of some bad stroke of luck; they were active and bold initiators of their own alienation.

The current school framework needs to change to present major critical barriers to the process of establishing model discourse communities. My students are homogeneously sorted and have few close positive role models. I meet with them for relatively little time, and have little control over how they engage the outside world as members of their intimate circles. They have learned to act in contrasting ways to what I intended and asked of them, and they resisted efforts to change. Because an entire restructuring of schools will transpire in the near future is unlikely, these aspects of teachers' work are also unlikely to change.

Reformers acknowledge that certain student groups are ignorant of scientific ideas and discourse, but fail to acknowledge that some of these same students are not predisposed to engage in classrooms where they are compelled to attend. Similar to the film *Field of Dreams*, reforms mistakenly promote the notion, "If you build it, they will come." Even though there is reference to changing the value of students, there is little direction or insight into how this process takes place in classrooms of alienated youth,--the keystone to the charge of "science for *all* Americans" as presented in the AAAS Project 2061 and other reform documents. My study captured some of the ways in which students' resistance to the curriculum and school as an authority increases their own alienation and, thus, complicates the problem of engagement. My study tests the abilities to change values, dispositions, and perceptions

against the backdrop of great challenges to make changes that run headlong into common features and practices of schooling.

Rethinking Effects of Tracking Students

Homogeneously sorted classrooms perpetuate destructive assumptions of both sides of the student-school equation. My students' placement in General Science was based as much on their fractured lives and resistance as it was on their fractured English or lack of science knowledge. Remediation did not help them and was not designed to get them back into the game. Their placement into special education was not helping them to do anything better or different. Their lower track placement was rarely reversed. Of the students who were on caseload with learning disabilities, none had ever been reintroduced into the mainstream, and some even had been in special education and pulled out of class in an excess of 10 hours per week for eight years.

The practice of tracking had a profound impacted on my students in the way they thought about school as well as their own lives. They were too familiar with their position in school, and the environment helped little to improve their position. Given the prevalent practice of tracking, I question the feasibility of making profound and wide-sweeping changes across the nation's schools.

Struggles and Resistance

Resistance should not only be expected from lower track students because successful students will resist change in different ways for different reasons. For example, successful

students resist because of the uncertainty of future success under different expectations. Students who traditionally failed will resist as a result of the continued skepticism of the entire educational process. Both dimensions of resistance are related to an intricate relationship between the social and intellectual fabric of a discourse community.

In the plight of such resistance, importantly my study paints a picture that supports taking control over students. It is a moral decision to change the ways students view one another and the world. I clung to my ideals and intentions for what I held for my students as I continually struggled to redirect, reprimand, and refocus class discussions. Spanning from the events structuring arguments with evidence to deciding we would talk about science, I continually fought for ground with my students.

One important lesson I learned about changing discourse patterns was that breakdowns of discourse brought to the surface many of our differences. Different expectations of opposing parties became very explicit in the tougher instances of my teaching. It was through major controversy, often aggressive, that I learned exactly "who" my students were and why my efforts were so foreign. Conflict came from confusion and ambiguity and this led to explication of certain expectations we both held but had not realized were so different.

Acquiring Instead of Learning Scientific Discourse

One important aspect of this charge involves understanding why students participate in the types of discourse they

practice. Many factors influenced how my students participated in my class. Schools ought to understand more about why students practice the discourse they do and why schools should try to invoke change. If scientific discourse is something we want to help students practice, knowing how what students already know and what parts can be useful in making a shift can make student acquisition of specialized discourse more feasible.

Subsequently, if further alienation or marginalization of students is to be avoided, finding value in parts of students' lives and discourse is difficult. Though it was difficult in the beginning to imagine what could be valued about the antagonistic backgrounds and learning difficulties of my students, finding out about their interest in radio controlled cars, their parents' vocations, their own interests to be a carpenter, and even their daily blunders with their favorite musical tape helped me to teach better. My students had much to offer and it was up to me to discover a way to channel their efforts in constructive ways. Though it was no trivial task, ways need to be found to value students and their contributions because it is central to engagement. As an institution, schools need to be sensitive to the needs and contributions of at-risk students.

IMPLICATIONS FOR RESEARCH

Studying What Happens to All Science Students

As a researcher, I did not feel that I had missed any big pieces of the picture before I entered the classroom. I had considered what it meant to know a scientific concept, and had

considered the history of science and science education and thought I understood what it took for students to discourse scientifically. I had studied and investigated how and when students make up their minds about certain phenomena and how and why scientific ideas get maintained and discarded in the discipline. I had even studied how student discourse and culture affected their school outcomes and events when home-based discourse could enhance learning.

When I turned to my data, however, I found I had large gaps of my thinking about these students. I had to read literature outside the accepted body of science education to make sense of what I was looking at. On the whole, I found the framework I had used to view students in lower track science classrooms was so large that it was difficult to examine the breakdowns in classroom discourse without refining my list of issues to a short list of categories, many of which came from other areas of research.

This, to me, suggests there exists a large gap between what is understood about alienated students in science and what teachers need to do within the context of real schools that practice sorting of students. Because of the confusion and smoke screen that student actions can promote, and the propensity for schools, teachers, and sometimes even researchers to dismiss the problem as only that of the students, I feel there is a need to recognize alienation, engagement, identity, and control as central issues in science classes. Researchers need to turn their attention to understanding more how these

aspects of school culture affect students in science. Clearly, from this study, students understand science only through the same type of mutually accepted ways they view their science classrooms.

Rethinking Central Issues of Science Education

As I return to reevaluate what I should have known before I entered my study I find there is very small bits of talking and writing about issues related to how lower track students understand and partake in science as a way of thinking or activity to engage in. At the same time, however there are discrepantly large conversations about a vision of science for all and a generic way to go about teaching and studying students learning science. From this gap there emerges a need to study what happens to not only lower track science students, but to all students as they interpret science through a larger social context. More needs to be understood about how all students understand science before grandiose charges of science for all Americans can be realized.

Finding New Ways to Discuss Scientific Literacy

This type of understanding can only occur when ways are devised to discuss and sustain different types of conversations about science teaching and learning. Discussing science more as a discourse among members of a community as opposed to a list of concepts to be learned is but one example of such a shift. When science educators change the substantive frameworks through which they view science classrooms new and forward theoretical

frameworks emerge as a way in which the community of scholars can best interpret a new students of problems, not unlike the social construction of ideas that we hope our students can derive. Educators need to depict science as something other than something to be "learned." Rather what reforms are asking for is a type of acquisition that naturally evolves through ways of thinking, speaking, and acting not unlike other forms of discourse that students must be engaged in through trial and error.

The notion of scientific literacy is changing as scholars talk about what we as science educators want from students. However, educators should note that much of this talk of scientific literacy did little to help me explain what types of problems I encountered or should anticipate in my next study. Science education, if there is such a discipline, needs to develop new ways of talking about science learning, teaching, nd scientific literacy if we are to better understand science classroom and ultimately influence the ways science is taught to "all" Americans.

APPENDICES

Appendix A.....269

Toulmin's General Argument Framework.....269

Appendix B.....270

Interview Protocol.....270

Appendix C.....273

Pre/Post Instruction Interviews.....273

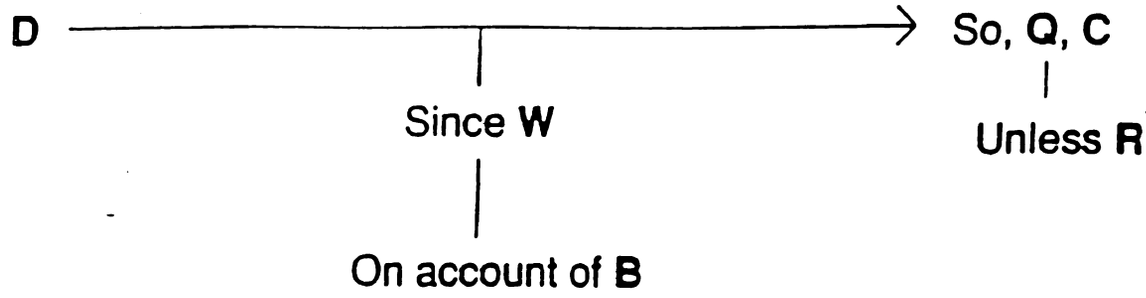
Appendix D.....276

Additional Notes About Analyzing Classroom Discourse..276

Appendix E.....279

Example Timeline From Chapter 5.....279

Appendix A
Toulmin's General Argument Framework



B = Backing
C = Claim
D = Data
Q = Qualification
R = Rebuttal
W = Warrant

Appendix B
Interview Protocol

Data Gathering

In order to assess changes in students' thinking based upon the instruction and the treatment of knowledge in the classroom context, I conducted interviews with nine of my students before and after 20 weeks of instruction. Each student was asked two identical questions in the pre and post interviews. Questions were situational and invited students into the problem to act as a scientist might to solve the problem. This protocol is similar to Warren and Roseberry (1991) interviews of students assessing their abilities to reason scientifically through the posing of tentative hypotheses. The two questions that the students were asked hinged around the explanations of why steel strings are required in electric guitars and explanations of electrical malfunctions in a newly refurbished science classroom.

Analysis

I videotaped all interviews with my students and viewed them both for the first time in their entirety after the post-interviews. During the second viewing of each interview I derived profiles of my students' responses in entrance and exit interviews. I made certain general claims about what differences I found in individual's responses and compiled these with those of the nine other students' responses. As I read through the claims that I had made about my students' thinking

both before and after instruction, I found that Toulmin's description was useful in qualifying claims I had made about the students. The language of warrants, data, backing, and claims were introduced to my original synthesis of students' responses.

I used the final viewing of interviews and reading of transcripts was used to clarify the use of Toulmin's argument model with the common phrases and the students' use of ideas. For organizational purposes these claims about student reasoning have been presented to reader as before and after categories.

Results

Three major shifts in students' thinking were noticeable over the course of instruction: (1) types of scientific explanations, (2) the use of evidence to support warrants, (3) and the view of authority. These shifts are noted in the following table according to the characterization of student scientific reasoning as well as their conformity to Toulmin's model for argumentation.

Scientific Reasoning	**Before**	**After**
What counts as a scientific explanation?	Students offer naive answers.	Students offer more sophisticated answers.
Toulmin: Warrants and answers	*Warrants are claims or factual answers.*	*Warrants are testable hypotheses.*

What does it take to answer a scientific question? *Toulmin: Evidence and Backing*	Students are naive observers of the world. *Backing is omitted from observations. Evidence lacks an interpretive framework establishing it's relevance through backing.*	Students are better investigators and observers. *Evidence is linked to warrants through an interpretive framework or backing.*
Who can answer a scientific question? *Toulmin: Authority over answers*	Students perceive others as the experts. *The process of argumentation as acted and imposed upon society by some third party.*	Students develop arguments to support their tentative claims. *Students perceive themselves as having an active role in argumentation as a process that appeals to evidence as a source of authority.*

Appendix C
Pre/Post Instruction Interviews

Interview #1

I'm going to tell you a story and I want you to respond to the story as if you are involved. It's about a musician, a guitar player to be precise. He is confused about something that happened and came to you to help figure it out.

One night while playing late at a night club, this lead guitarist broke a string. He was frustrated when he found only acoustical guitar strings made of nylon in his repair kit instead of steel guitar strings for his electric guitar. Frustrated that he had brought the wrong kit and knowing that he had to play another hour before closing, he tried to replace the steel string with the acoustical string he had brought. After all, it was only going to be an hour and these strings worked in his other guitar at home. He found that string made no noise that could be heard through his amplifier and speaker. He was forced to quit for the evening as no one else in the band had any spare strings either.

This event bothered him as he thought more about it. He wondered how it could be that the string would act the same on both guitars but only one of them could be heard with an amplifier. He even thought that maybe a great invention would be a nylon acoustical string that could be used in an electric guitar with an amplifier.

You are a scientist. This friend comes to you to ask you why the two strings act so differently in the electric guitar.

He also wants to know about his invention of a string that can perform in both places. You are not sure but have some ideas.

On Experimentation

What will you do to find out what the problem is?

What is the first thing you will do?

What will you tell him is wrong?

Do you have any ideas about his invention?

On Argumentation

How will you find out if you are right?

What would you say to someone who disagreed with you?

What if someone said that they thought that both strings should work equally well? What if they said it was the acoustical guitar was made of wood and wasn't plugged in?

Interview #2

I'm going to tell you a story and I want you to respond to the story as if you are involved. It's about students in a classroom that has been recently remodeled and is responsible for some strange events. Everyone likes the new classroom but no one knows exactly what is wrong.

The classroom has been refurbished with new desks, lab benches, carpeting, curtains, phones, PA systems, computers, and lab equipment. It has been noted that people get electric shocks when using the pencil sharpener, door knobs and latches, and gas jets. Candy wrappers and folders are sticking to the desks and blackboard. The strangest events are happening with the computer. The computer that the teacher had at home for the

summer is now freezing up for no apparent reason. Computer disks have been erased while simply sitting on the teacher's desk. Several of the students' lab write-ups have disappeared from the information stored on computer disks and this is becoming a problem in grading.

You are a scientist that lives next door to the school and are called upon by the teacher to fix the problem. Everyone likes the new classroom but would like things to be back to normal.

You are to make your recommendations to the principal as to what the problem is and what can be done.

On Experimentation

What will you do?

What is the first thing you will do?

What will you tell them?

Do you have any ideas about how to fix the problem?

On Argumentation

How will you find out if you are right?

What would you say to someone who disagreed with you?

What if someone said that they thought that it was bad computer discs? A short in-wiring in the walls of the classroom?

Appendix D
Additional Notes Concerning The Analysis of Classroom Discourse

Analysis of classroom discourse was sampled in the general forum of class. The main discussions that served as the skeleton for Chapters #3 through #5 were captured in the general venue of whole class discussions. When students are not vocal in the classroom discussion, they were either absent from class or chose not to engage in the discussion. The class size diminished from 18 to 13 students by the end of 20 weeks data collection.

The first stage of analysis of the classroom discourse was to identify critical events that shaped the course of instruction. This process took three steps

1) Examining a daily chart of events that catalogued all my videotapes as well as my teaching journal. There were more than 60 events documented with small notes to indicate their location on videotape and informally labeled with a summative comment like, "Kevin freaks out about someone narcing on him." These often turned out to be emotionally charged and complex interactions that at first made little sense.

2.) I made a timeline of the complete class in which this critical event occurred. If the event was informed by other circumstances that preceded it (references made by students to other incidents, etc.), the timeline was extended before and after which noted general characteristics of the discourse of that event. An example timeline of Chapter #5 is included in Appendix E.

3.) I wrote stories that tried to tell of the important issues that my students and I grappled with. The stories were used as analysis tools as they were framed with a plot, a point, primary and secondary characters, a theme, and background. Important transcriptions were included to capture both the point I was making and the voices of my students. Pseudonyms were introduced to the stories and maintained consistent throughout to develop the

primary players. Each of these stories were written separately, revised, and later returned to in their entirety to identify common themes that connected each of the stories. These stories included important transcriptions

The second stage of analysis examined arguments within the stories and interviews. Once the stories were constructed I further analyzed the arguments about subject matter that transpired during these events. I grouped responses across the stories into many categories that I thought exemplified important components of the discourse of class. Some of the major categories that I used in this analysis are as follows:

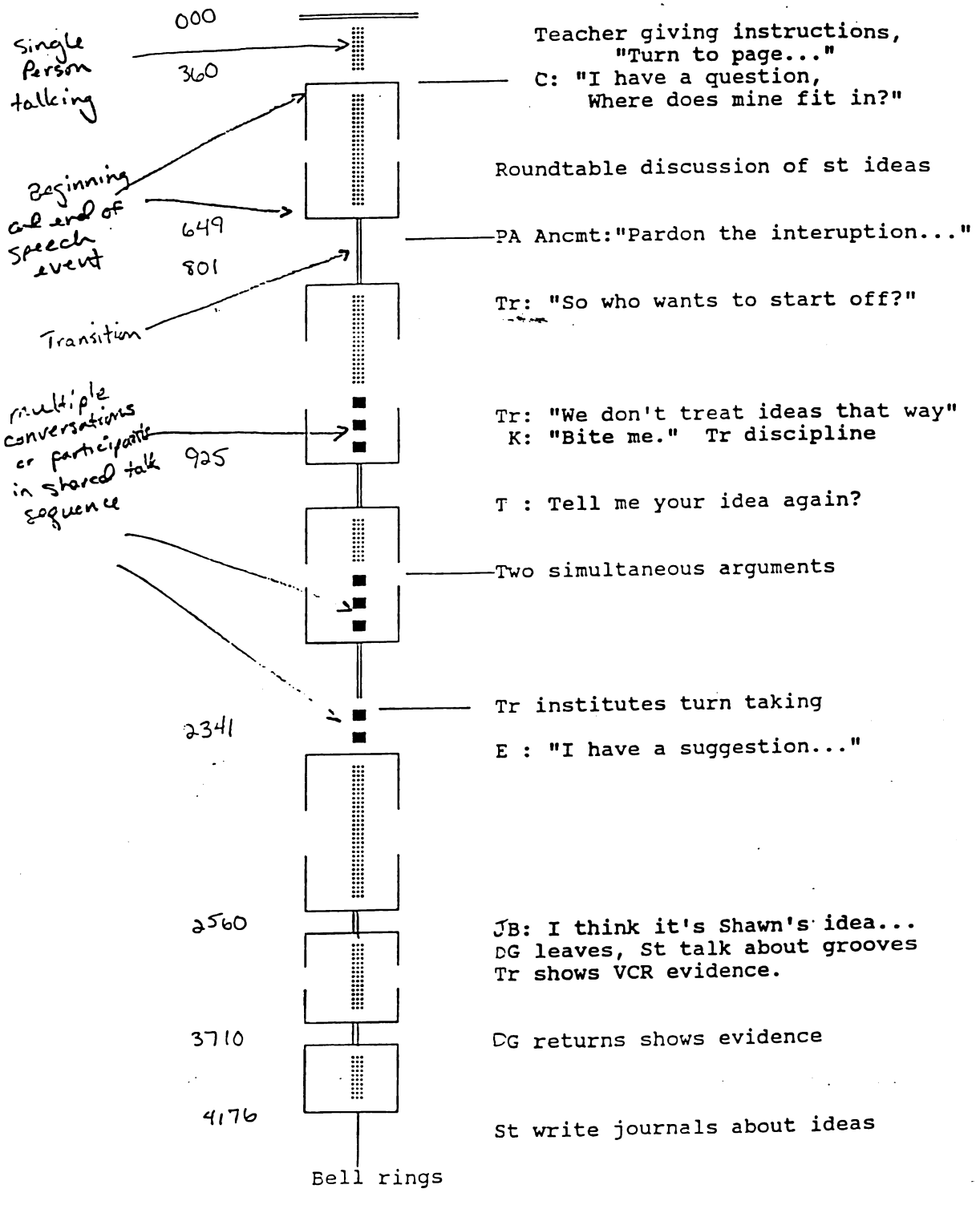
Category	**Example**
Warrants	"I think that..."
Tentative nature of knowledge	"Maybe..." "If...then..."
Use of evidence	"That's because...happened" "If that were the case then...would happen."
Status	"My classmates make me feel like I'm nothing." "You just want to cover your..." Emotional responses that evoked embarrassment or sometimes laughter.
Influencing class procedures	"Why don't we..." "You _C' do something Mr. Yerrick."
Alienation	"It's none of their business what we do after 2:35 PM." Specific usage of WE and THEY
Control	Overt use of directives like, "(you) Sit down." or "(you) Be quiet." Punitive measures like, "You are warned." or "Go sit in the room, please."

After defining the key components of discourse that I felt characterized the issues and changes I was observing, I made frequency counts in each of the transcripts. I did this for three purposes. First, I was interested in my own consistency of these categories throughout my stories. Second, I wanted to account for changes in the frequency or use of these categories from the beginning to the end of my data. Finally, I wanted to compare my quantitative counts to those of an independent rather who viewed the arguments and made his own frequency counts.

As a third and final step of data analysis I returned to the interviews to find some individual differences in the ways students constructed their arguments. I then examined the arguments of each story in an attempt to account for how the instructional setting contributed to the change in the responses of the students. Some of the questions I asked as I returned to the transcriptions of arguments included:

- Who are the major players in the argument?
- What is their role in the argument? Antagonist? promoter of new ideas? Facilitator?
- Who are the minor players? Are there clues to infer the reasons for their abstinence or silence?
- Whose ideas get discussed?
- Whose ideas are left hanging without discussions?
- What are the social relations between primary players, secondary players, and their relative social status?
- What kinds of reasons are used to convince others?
- What are the agreed upon rules of engagement (what evidence is acceptable, omitted, etc.)

Appendix E
Example Timeline From Chapter 5



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