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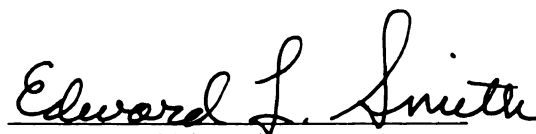
KNOWLEDGE, LANGUAGE AND SUBJECTIVITIES IN A DISCOURSE
COMMUNITY: IDEAS WE CAN LEARN FROM ELEMENTARY CHILDREN
ABOUT SCIENCE

presented by

Lori Ann Kurth

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Teacher Education


Major professor

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**KNOWLEDGE, LANGUAGE AND SUBJECTIVITIES IN A DISCOURSE
COMMUNITY: IDEAS WE CAN LEARN FROM ELEMENTARY CHILDREN
ABOUT SCIENCE**

VOLUME I

By

Lori Ann Kurth

A DISSERTATION

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

DOCTOR OF PHILOSOPHY

Department of Teacher Education

2000

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ABSTRACT

KNOWLEDGE, LANGUAGE AND SUBJECTIVITIES IN A DISCOURSE COMMUNITY: IDEAS WE CAN LEARN FROM ELEMENTARY CHILDREN ABOUT SCIENCE

By

Lori Ann Kurth

In light of continuing poor performance by American students in school science, feminists and sociocultural researchers have demonstrated that we need to look beyond content to address the science needs of all school children. In this study I examined issues of discourse norms, knowledge, language and subjectivities (meaning personal and social observations and characteristics) in elementary science. Over a two-year period, I used an interpretive methodological approach to investigate science experiences in two first-second and second grade classrooms. I first established some of the norms and characteristics of the discourse communities through case studies of new students attempting to gain entry to whole class conversations. I then examined knowledge, a central focus of science education addressed by a variety of theoretical approaches. In these classrooms students co-constructed and built knowledge in their whole class science conversations sometimes following convergent (similar knowledge) and, at other times, divergent (differing knowledge) paths allowing for broader discourse. In both paths, there was gendered construction of knowledge in which same gender students elaborated the reasoning of previous speakers. In conjunction with these analyses, I examined what knowledge sources the students used in their science conversations. Students drew on a variety of informal and formal knowledge sources including personal experiences, other students, abstract logic and

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thought experiments, all of which were considered valid. In using sources from both in and out of school, students' knowledge bases were broader than traditional scientific content giving greater access and richness to their conversations. The next analysis focused on students' use of narrative and paradigmatic language forms in the whole class science conversations. Traditionally, only paradigmatic language forms have been used in science classrooms. The students in this study used both narrative and paradigmatic language by drawing on stories of personal experience as well as canonical scientific argument. As had the varied knowledge paths and sources, the use of both language forms contributed to a broader and richer scientific discourse. Finally, in studying students' written discourse through their journals, I found that students had expanded views of science as they incorporated many aspects of their subjective selves including self and human elements, thinking, emotions, etc. in their writing and drawing. The enactment of knowledge, language and subjectivities in these discourse communities was unique, rich and meaningful highlighting a broader, more accessible vision of science. I advocate that knowledge, language and subjectivities should be central concepts in the practices of science communities as demonstrated in these classrooms. In establishing and integrating these concepts, the use of alternative and traditional modes of expression should be supported as both necessary and complementary. Students and teachers must also jointly construct classroom discourse norms, talk and writing in specific ways in order to provide a safe, comfortable and meaningful learning environment. Many teachers, students and scientists would benefit from broader visions of science, which enrich scientific knowledge and practice and engage and value participants from many backgrounds.

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INTRODUCTION

Introduction

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Chapter 1

INTRODUCTION: SEARCHING FOR AN EQUITABLE, INCLUSIVE SCIENCE WITH CHILDREN'S VOICES

Introduction

This study is an attempt to capture important “moments” of elementary students’ interactions with science. I had the fortuitous opportunity to participate in two elementary classrooms where students and teachers were engaging in science in wonderful and exciting ways I had not previously seen. I tried to understand the specifics of some of these interactions in order to share them with others.

I was particularly drawn to the contagious enthusiasm of the students and teachers in these classrooms because of my own mixed excitement and discouragement with science research. In this chapter I give a brief overview of my experiences which led to a search for a more equitable, inclusive vision of science, one I found in these classrooms.

My Previous Experiences with Science Research and Teaching

My professional interest in student access to school science and alternative representations of science is strongly connected to my background in both education and science. My undergraduate work at a state university focused on science with a dual major in biology and chemistry. I entered college wanting a practical degree and found that I was proficient in science course work. As I began taking more advanced science classes, I became enmeshed in richer understandings of scientific knowledge and was intrigued by the intellectual challenges of scientific research.

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I followed my undergraduate degree with scientific research experiences in state and university laboratories. In these settings I worked on basic research in environmental studies and oncology. Through these experiences I gained an understanding of the variety and utility of research techniques and enjoyed the satisfaction of pondering mechanistic questions in the systems I studied. As I developed expertise, I longed to share the excitement, elegance and power of science that I encountered in the research setting with students who were only acquainted with science in dull, dry textbooks. I, therefore, completed a post-baccalaureate teacher certification program at a state university, which focused on academic learning in secondary chemistry and biology.

While I was fully immersed in secondary teaching, I realized how much I missed research and sought to combine my dual interests in a doctoral program in biochemistry. However, the structure of the program permitted me only minimal teaching experiences. My advisors informed me that I needed to make research central to my career and that teaching had to be a subordinate interest. I, therefore, attempted to follow traditional, scientific cultural norms that stressed the development of my research skills. Although I experienced a great deal of success and enthusiasm for research, I grew dissatisfied with my singular focus and knew that I needed to explore alternative science environments where my teaching could be developed and valued. With the advice and support of science education faculty, I decided to enter a doctoral program in science education at a state university. I wished to remain in touch with basic science research, however, and so continued part-time scientific research in oncology during my doctoral program.

Early in my science education doctoral program, I concentrated on teaching pre-service elementary majors in a small liberal arts college. I was an instructor of a science methods course for two years, a field instructor for student teachers and a team instructor

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for an integrated summer field course at the college. I later also taught pre-service elementary teachers and interns in science methods courses at a state university.

While teaching at the liberal arts college, I began educational research as coordinator and investigator of a grant project that examined pre-service elementary teachers' science content understanding and teaching in a collaborative team of pre-service elementary teachers, cooperating elementary teachers, education faculty and science faculty. Through interviews for the research program and interactions in the classes I taught, the students gradually became comfortable expressing their true feelings about science. Many of the elementary majors spoke of their personal disinterest in science, but they also felt they had an obligation to teach science to their students. Others told of extreme fear, dislike and even hatred for science. Some were indifferent and did not understand why we were talking about science at all. They did not think it was a subject for elementary school and should be dealt with by middle school teachers. Their stories were both moving and disturbing to me. Since recently experiencing my own difficulties fitting into scientific communities, I could partially relate to their dissatisfaction. Even so, I had also experienced the beauty and power of deep intellectual engagement with scientific research and wanted to help students see more promising alternatives to the science they may have learned in school. As many of the students were women, I began to draw on feminist theories (Harding, 1991; Hubbard, 1989; Keller, 1985) which provided critiques of science, offered alternative conceptions of science and helped me to explore gender issues as I examined students' alienation from science in school.

In addition to studying students' perceptions of science, I began researching my position as a teacher in the classroom and further examined the influences of my scientific training on my teaching approach. With the support of a feminist scholar group in science

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education, Women in Science Education, I collaboratively studied my teaching and background in science with women who had similar experiences and concerns.

The examination and reflection of my teaching have led me to a constructivist teaching philosophy informed by feminist theory. I begin my pre-service classes with students' personal experiences with science. Often, it takes considerable effort for students to face their disinterest or alienation with traditional science. I strive to help them see that science is a part of their lives every day and encourage them to help their elementary students see the science in their own lives. I then invite students to more closely examine the roots of their own initial dissatisfaction with science. I draw on feminist and multicultural critiques of science that explicate the exclusive, elitist European male origins and traditions of science. After making personal connections and critiques of science, I approach unit planning with deep understanding of science as central. Conceptual change theory and practice (Berkheimer, Anderson & Smith, 1992; Lee, Eichinger, Anderson, Berkheimer & Blakeslee, 1993; Posner, Strike, Hewson & Gertzog, 1982; Smith, 1990; Smith & Anderson, 1984; Strike & Posner, 1992) provide the base interwoven with students' previous work in personal engagement and critique. Together we work towards the cultivation of an inclusive, comfortable and meaningful classroom community.

Along with the research and development of my own teaching and pre-service elementary majors' conceptions of science, I have also concentrated on educational research concerning elementary, middle and high school students' social interactions with science. In particular, I have become focused on how students' discourse influences their inclusion or marginalization in the school science community and how students' personal relationships with science develop. In my college teaching I observed that many of the

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pre-service elementary teachers who had strong feelings of dislike for science were women. The few men students in my courses largely felt more comfortable with their previous science experiences in school. In my research with K-12 students, I wished to further examine how girls' experiences with science differ from boys' and how culture and class influence student community and personal identity in science. I continue to draw on feminist theory and also sociocultural literature to frame my work. Feminist frameworks have been useful in understanding students' alienation from traditional science and envisioning alternative representations of science. Sociocultural theoretical frameworks have helped me to understand the complexity and importance of social and cultural influences on students' school experiences, especially students' use of language (Gee, 1991; Heath, 1983) and particularly in science contexts (Lemke, 1990).

The Focus of This Study

These experiences brought me to my dissertation setting where I spent four years working with a multicultural elementary professional development school with a large international population of beginning English speakers. As I observed the students and teachers working together in these classrooms, I became very intrigued with students' ease and interest in science. They appeared sincerely engaged in science thought, talk and activities in their classrooms. This setting was a stark contrast to my previous experiences both personally and teaching pre-service elementary majors in which many of us had difficulty gaining entry to scientific communities or ways of thinking. The ready engagement and participation in science exhibited by the elementary students in this school were striking. This unusually broad access to science led me to pursue a deeper examination of the educational practices in this community. I wanted to learn more about what was going on in the classrooms that created such high levels of engagement and

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involvement with science. I wished to thoroughly document the wide access and equitable participation practices to ensure that they were actually occurring and to then share specifics of these practices with other educators. I had many questions to investigate in this promising setting. What was really going on? Were the apparent high levels of access and participation by students in science really happening? If so, what specifically made these classrooms accessible and engaging places to learn science? Also, how were the teachers able to encourage and facilitate such meaningful talk and thinking about science in young children?

Some of the answers to my questions were found in the professional development work undertaken by the school as a whole community. Part of this work involved developing and fostering science and literacy integration through an all-school focus. The teachers and university educators developed oral discourse as a key feature of science teaching and learning. Together they created a list of oral discourse components, explicit moves to facilitate both equitable and meaningful conversation in science. The features of this work seemed worthy of careful investigation and documentation for a number of reasons. While there has been an ongoing emphasis on talk in science classrooms nationally, the focus on *science* and *literacy* in this school seemed particularly fruitful. The educators seemed to bring together the best qualities of both disciplines to bear on productive science conversations. In particular, the focus on conversations that were both *equitable* and *meaningful* was a key strength of their work. The staff drew on literacy research to develop conversational moves that created equity and safety among the students as they expressed tentative ideas. For example, one of the oral discourse components was *encouraging* others to participate, an explicit move to facilitate all students' taking part in the conversations. At the same time, the teachers and university

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educators also used Toulmin's argument framework (1958) to ensure authentic, meaningful conversation about scientific ideas. Two of the oral discourse components derived from Toulmin's framework were *making claims* and giving *reasons*. In their science conversations students would propose an idea or fact (*make a claim*) and then give support with a compelling *reason* to persuade others of the idea's usefulness.

The development of these innovative and productive practices was made possible by the combined efforts of teachers and university educators working together on a particular focus, integration of science and literacy in students' oral discourse. As a member of this community, I was fortunate to work in classrooms where these curricular changes were enacted to facilitate meaningful, comfortable and equitable peer conversation in science.

For my dissertation research I decided to focus on two classrooms, a combined first-second grade classroom and a second grade classroom, that exemplified the key features of the whole school's professional development work. The teachers in these classrooms created a unique whole class science conversation format where students discussed a particular issue using oral discourse components in the form of *agree* and *disagree* statements with *reasoning*. The *agree* and *disagree* format encouraged maximal student participation and multiple opinions. The teachers' fostering of particular oral discourse moves such as *agreeing*, *disagreeing* and *reasoning* also provided a rich context to contribute to previous research about student conversation in science (Gallas, 1995; Hatano & Inagaki, 1991).

I attempted to determine what norms and values underlay this discourse community. Though the organizational structure seemed to expand the discourse, I also saw some patterns of constraint for particular students. Through informal

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conversations and interviews with the cooperating teachers, we continued to refine the conversational structure to encourage even more students to participate.

Using the theme of expanding classroom discourse, I found Kathleen Weiler's (1997) concepts of knowledge, language and subjectivities to be a salient framework for this research. I attempted to gain a better understanding of the relationship between students' personal backgrounds and experiences and their construction of knowledge in school science. In addition, I was interested in how this relationship was expressed through students' use of language with emphasis on the specific forms of language used. Finally, I wanted to learn how students expressed their subjectivities (personal and social observations and characteristics) in their science conversations and writing.

Learning from Children

In addition to the wonderful classroom practices and insights developed by the teachers, central to my work have been the children in these elementary classrooms. I continually learned from them new and exciting ways of experiencing science. I share with Bronwyn Davies (1993), Margaret Himley and Patricia Carini (2000) and Barrie Thorne (1993) a sincere interest in understanding children's perceptions of science from their own viewpoints. Barrie Thorne (1993) describes the challenges of such work. "To learn *from* children, adults have to challenge the deep assumption that they already know what children are 'like,' both because, as former children, adults have been there, and because, as adults, they regard children as less complete versions of themselves" (p. 12).

In confronting these assumptions, we learn to respect and value the ideas of children. Thorne (1993) discusses the transition of moving beyond adult assumptions to appreciate a child's vantage point.

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...I wanted to overcome these barriers and to approach their social worlds as ethnographers approach the worlds of adults: with open-ended curiosity, and with an assumption that kids are competent social actors who take an active role in shaping their daily experiences. I wanted to sustain an attitude of respectful discovery, to uncover and document kids' points of view and meanings. To adopt that basic stance means breaking with an array of common adult assumptions: that children's daily actions are mostly trivial, worthy of notice only when they seem cute or irritating; that children need to be actively managed or controlled; that children are relatively passive recipients of adult training and socialization. (p. 12-13)

I, too, see children's work in school and outside as intentional and competent. In this study I wished to more fully understand children's perceptions of science and learn from them. Thorne reflects on the idealized notion "that children are more sensuous and open to the world than adults, and that adult creativity hinges on overcoming repression and gaining access to the child within" (p. 16). Like Thorne I believe that there are innumerable ideas we can learn from children's creative and open views of science. I invite the reader to experience and learn science through the children's eyes in this study.

Contribution of This Study

The central problem I encountered as a scientific researcher and observed in my teaching of pre-service elementary teachers was in gaining access to traditional scientific communities and ways of thinking. With the help of others experiencing similar difficulties, I sought alternative conceptions of science that welcomed the perspectives of many, varied participants. I see my dissertation work as providing a contribution towards increasing student access to broader views of science. First, this study provides a rich description of innovative science teaching and learning in a professional development school setting. Second, it explores and brings attention to valid, alternative ways of representing science that are complementary to traditional modes of expression. Third, the

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This work serves as a basis for my future research interests. I plan to deepen and integrate my understanding of feminist and sociocultural theoretical perspectives as I intertwine them with my own work. These theoretical perspectives have helped to illuminate the disturbing patterns of women's and minorities' alienation from science. I hope to use my dissertation insights to contribute to the field at the elementary school level. I wish to better understand and refine children's science conversations and writing so that they are more equitable, comfortable and meaningful for students.

Organization of This Dissertation

Following this introduction I review some key work in feminist and sociocultural research in the next chapter and relate it to current research areas in science education. Chapter 3 outlines my interpretive methodological research methodology with specific details of data collection and analysis. The particular analyses are then organized into four conceptual categories: discourse community norms, knowledge, language and subjectivities. Chapter 4 describes the classroom settings and discusses the first analysis of norms and characteristics of the discourse communities elucidated through case studies of new students. Chapter 5 describes the analysis of knowledge in students' science conversations focusing on knowledge construction and sources. Chapter 6 then examines the use of narrative and paradigmatic language forms in the students' conversations. Chapter 7 turns to students' journal writing and drawing for an analysis of the presence of subjectivities (personal observations and characteristics) themes. Finally, chapter 8 reviews the findings, looks at trends across analyses and considers implications for research and teaching.

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Chapter 2

FEMINIST AND SOCIOCULTURAL THEORETICAL PERSPECTIVES IN SCIENCE AND EDUCATION

Introduction

In this literature review I describe a few key constructs from feminist critiques of science and from feminist and sociocultural work on the social context of discourse. The purpose of this review is to give the reader a detailed summary of a few authors who have greatly informed and shaped my theoretical perspectives. The review, therefore, is not comprehensive but instead focuses on clearly communicating ideas critical to my work. I then address how these constructs can be useful in envisioning a broader view of science and studying social influences on student access to elementary science discourse. Finally, I discuss more generally how these ideas relate to other work in science education and give an overview of the specific conceptual framework for this study.

Feminist Critiques of Science

Many feminists in science have provided strong critiques of traditional science that reveal both blatant and subtle male bias by European and European American men who have had control of publicly recognized science. As feminist writers show us the sexism within science, they also point to different imaginings of science that would recognize and honor the contributions of people who have been marginalized or excluded from traditional science. These people are primarily women and minorities.

The following authors have developed some important ideas for the critique and revisioning of science. Evelyn Fox Keller takes a historical look at the masculine roots of

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science and uses psychoanalytic theory to understand the connections among masculinity, autonomy, objectivity, power and control in science. Through an ethnographic study of the world of particle physics, Sharon Traweek demonstrates the overwhelmingly male makeup and perspectives of this community. Ruth Hubbard shows us that the seemingly objective, apolitical, acultural and value free science defined by the particle physicists as well as many other scientists is a well concealed myth. Feminists have recently disclosed this myth by revealing the social nature of science as well as the many contributions of women that have previously gone unrecognized. Sandra Harding redefines the scientific notion of objectivity to include the subject of research (as well as the object) and to emphasize the critique of marginalized groups. Donna Haraway further contributes to the objectivity debate by describing the partial, situated nature of knowledges in contrast to traditional conceptions of a context-free, neutral, complete truth. All of these authors show the many problems with traditional science as a narrowly defined, male enterprise and offer ways to reconceptualize science as a more productive, inclusive, humane endeavor.

Science as a Masculine Enterprise-Autonomy, Objectivity, Power and Control

Evelyn Fox Keller (1996) describes a range of masculine bias in science that extends from conservative to radical notions. On the conservative end, most people might agree that women have not been represented in science in terms of sheer numbers working in the field and as objects of study. While more women participate in the enterprise today, they tend to be often located in the 'soft' sciences. Many would argue that we need to find ways to get even more women and minorities into science fields. That would correct the present European male imbalance.

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I am more interested, however, in the other end of the argument, the radical position that questions the nature of science itself. We have all been taught the objective, rational nature of science. Indeed, this is science's supposed strength. The power of science comes precisely from its ability to understand and explain the *truth* about nature. Its mission is to obliterate all forms of bias so that *real* understandings of nature can be obtained. Keller and other feminists, however, question this very foundation of scientific ideology. She states

To challenge the truth and necessity of the conclusions of natural science on the grounds that they too reflect the judgement of men is to take the Galilean credo and turn it on its head. It is not true that 'the conclusions of natural science are true, and necessary, and the judgement of man has nothing to do with them,' it is the judgement of women that they have nothing to do with. (p. 30)

Keller cautions us that one possible outcome in rejecting masculine objectivity and embracing female subjectivity is total relativism. She states that we must distinguish "the objective effort from the objectivist illusion" and argues for a "refining" of objectivity. To do this we must add critical self-reflection to the standard processes of rational and empirical inquiry. Then we can understand the human features of science "that belie its claim to universality."

Keller uses psychoanalytic theory to explain how objectivity has been linked to autonomy and masculinity. She states that the "early maternal environment, coupled with the cultural definition of masculine (that which can never appear feminine) and of autonomy (that which can never be compromised by dependency) leads to the association of female with the pleasures and dangers of merging, and of male with the comfort and loneliness of separateness" (p. 33). With Piaget and others, she argues that objectivity (separation of self from other) concurrently develops with the need for autonomy. As

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autonomy is associated with the male, objectivity also comes to be thus associated. Psychological and social pressures lead these categories to become exaggerated and rigidified leading to an exalted status for objectivity and a subsequent devaluation of “(female) subjectivity.”

Keller extends this argument to explain how the goals of science have been linked to power and domination. She first considers the psychic development of the young child. As the child seeks autonomy, there is a divisive pull between the positive aspects of autonomy in competence and the negative aspects of being alone. The child wishes to compensate for the loneliness by somehow relating to the other. Drawing on D. D. Winnicott’s work, Keller suggests that the child may also have a fantasy of destroying the object in order to achieve autonomy. The child can balance this division between destroying the other or destroying one self by mastering the other. The balance is achieved by the male child identifying with the father and consequently denying (or mastering) the mother.

This same argument can be expanded to our notions of science. Keller goes on to “suggest the impulse toward domination does find expression in the goals (and even in the theories and practice) of modern science, and argue that where it finds such expression the impulse needs to be acknowledged as projection” (p. 35). These inclinations toward domination in science arise from the “cultural construct of masculinity.”

Keller is quick to acknowledge the consciousness that we all have as individuals in making choices about power and control in science. However, she also convincingly traces the influential, historical connections Western men have made uniting objectivity with power and control in science. She cites Francis Bacon’s conception of knowledge

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and power as one. He believed that science is “‘leading to you Nature with all her children to bind her to your service and make her your slave,’ by means that do not ‘merely exert a gentle guidance over nature’s course; they have the power to conquer and subdue her, to shake her to the foundations’” (p. 36).

She gives us a contrasting vision of science, one that embraces female as well as male characteristics in her description of a woman scientist, Barbara McClintock.

...consider a contemporary scientist who insists on the importance of ‘letting the material speak to you,’ of allowing it to ‘tell you what to do next’-one who chastises other scientists for attempting to ‘impose an answer’ on what they see. For this scientist, discovery is facilitated by becoming ‘part of the system,’ rather than remaining outside; one must have a ‘feeling for the organism.’ (p. 37)

This way of doing science is not the domain of women alone. Many other scientists have described their work in similar ways, of having a “conversation with nature,” rather than “dominating nature.” However, historical study shows that the view of science as domination of nature has been predominant.

One reason is that the people who have chosen to do science are intrigued by the “power and control” ideology of science and have perpetuated that ideology in their work. A current example of this ideology exists in cellular biology. Theories of “steady state” interactions of cellular organelles once competed with the hierarchical models of a “master molecule.” DNA (deoxyribonucleic acid), the master molecule, won out leading to the central dogma that DNA contains the messages of life that get translated and sent to all parts of the cell and beyond. This central dogma has produced a proliferation of work in molecular biology today.

Compared to the central dogma, Barbara McClintock’s understanding of DNA and its role in the cell was much more interactional and nonhierarchical. The DNA

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responds to stimuli in its environment rather than dictating directions for the environment to follow. Keller states that we can find other examples of scientists like Barbara McClintock who have not followed the masculinist tradition of power and control in science. Ultimately, science is a “pluralistic” enterprise, and examples of nontraditional scientists can give us a real vision of a multifaceted science. We need to highlight these dimensions of science that have not received due attention in the past.

The Maleness of Traditional Science

Barbara McClintock clearly represents a startling alternative to traditional perceptions of science. To gain a more complete picture of how many contemporary scientists are still influenced by the dictates of their European forefathers, I turn now to a recent study of a specific scientific community. In her examination of particle physicists, Sharon Traweek (1988) brought to the surface many of the male features present in this science discipline. She reports that the vast majority of scientists in this field are men and that the stories told by them must, of course, be “male tales.”

Traweek documents the male characteristics of a physicist’s training. Beginning with undergraduate education, physics students learn the history of their discipline. This history, however, is brief and restrictive, confined to the margins of their textbooks. Here are the recent heroes of physics. White men, in standard dress, are photographed alone in neutral pictures with bland backgrounds. Traweek summarizes the messages of these photo histories as follows:

There is, it seems to me, a cluster of subliminal messages in these picture captions: that science is the product of individual great men; that this product is independent of all social or political contexts; that all knowledge is dependent upon or derivative from physics; that only a very few physicists will be invited into the community of particle physics; and that the boundaries of particle physics are rigidly defined. (p. 78)

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Traweek goes on to describe how the photos represent culture or the lack of it in the particle physics community.

Scientists of all nationalities-Swiss, German, Italian, Scottish, English, French, Australian, Polish, American, and Japanese-look as alike as possible in this portrait gallery, signifying that culture is not an issue among them. Listing the names and varied birthplaces again suggests that scientists emerge in all cultures; the implication is that science and an aptitude for it are independent of variables like culture. Most physicists would argue that there are no cultural influences on their activities as scientists. (p. 78)

By maintaining the lack of cultural and political influence on their work, the scientists strive to maintain fluid relations with colleagues in other countries. In this way they all have access to the few major research centers necessary for their work.

In addition to an apolitical and acultural portrayal of physicists, undergraduate students also learn that there is a hierarchy in the disciplines with physics, of course, at the top. The other natural sciences, chemistry and biology, follow physics, with the social sciences and humanities at the bottom. Mathematics and art are not included in the hierarchy as they represent rigor and creativity, essential elements to physics itself.

As students proceed through graduate school, they learn about their appropriate social positions. It is best to be married, and *wives* of physicists are devoted to supporting their husbands' work. While many wives pursue their own careers, the physicist husbands determine major decisions such as geographical job locations. Unmarried or divorced men's liaisons are gossiped about in the physics community, but married men's personal relationships are not discussed. The personal liaisons of unmarried men are considered to be useless distractions from their work.

Postdoctoral fellows learn a different version of history than they received as undergraduates. They learn "local nostalgia" about the equipment and their group leaders.

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They also learn more generally that the current state of knowledge in their field is useful for only about six months. Those who pursue history beyond that are either old physicists who do not “have any physics left in them” or science historians who could not make it in physics.

During this time young physicists also learn to develop a personal style that is confident, aggressive and abrasive. Despite the ruse of group cooperation, physicists learn to definitively and forcefully criticize other scientists’ findings while striving to make their own accomplishments that will raise them above their peers. While this style is essential for success, physicists themselves see a democratic entry but competitive market for those who stay in the field.

The physicists see themselves as an elite whose membership is determined solely by scientific merit. The assumption is that everyone has a fair start. This is underscored by the rigorously informal dress code, the similarity of their offices, and the “first naming” practiced in the community. Competitive individualism is considered both just and effective: the hierarchy is seen as a meritocracy which produces fine physics. American physicists, however, emphasize that science is not democratic: decisions about scientific purposes should not be made by majority rule within the community, nor should there be equal access to a lab’s resources. (p. 91)

Traditional notions of objectivity and authority permeate the particle physics community. To be concerned with the social and psychological dimensions of the group would be “unscientist-like.”

Social eccentricity and childlike egoism are cultivated displays of commitment to rationality, objectivity, and science. Young scientists often assert their ignorance of human motives, of everything “subjective,” as if that confirms their vocation. Development of insight into one’s own motives and actions is thought to be a diversion of time and attention better spent on science. One experimentalist has told me that he believed a successful postdoc had to be rather immature: a mature person would have too much difficulty accepting the training without question and limiting doubts to a prescribed sphere. He felt that this precondition kept

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most women and minorities from doing well: their social experience had taught them to doubt authority only too thoroughly. (p. 91-92)

With these and other examples, Traweek shows us how contemporary particle physics is still very much a male domain. Men's experiences have shaped the community and the science. From the seemingly aloof, neutral, apolitical and acultural portrayals of science heroes in textbooks to the incessant demands on physicists in training to be confident and aggressive pursuers of truth, these men have created and maintained a science that is authoritative and objective (by their standards) and denies politics, culture and human experience, especially the experiences of women and minorities.

Traweek brings our attention to these male perceptions of particle physics and shows us why traditional science has been alienating to minorities and women. Other feminists take further issue with features of male-created science such as objectivity. Fortunately, many feminists also provide us with alternative visions of how science might be more receptive and valuing of women's experiences.

The Social Nature of Science and Women's Contributions

Ruth Hubbard (1989) closely examines the "facts" of science. She claims that facts are not out in the world waiting to be discovered as we are often taught in our science classes. She asks us instead to consider the many aspects of the world and to wonder why some become fact, others fiction, and still others go unnoticed.

Hubbard states that "making facts is a social enterprise" (p.119). Individuals do not go off on their own and create facts. These facts must be in agreement with what others think, or people may be forced to agree with them. In any case, it is a "human enterprise."

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As a human enterprise the scientific community, the doers of science, then shape science. Hubbard describes the qualifications necessary to become a member of this community. One must have a particular, advanced education to the post-graduate level. During this training scientists learn specific subject matter and how to think and talk in ways befitting of their occupation. They also learn that “narrow slice of human history and culture that deals primarily with the experiences of western European and North American upper class men during the past century or two” (p. 120). Until recently, the people who have had access to this knowledge were only middle or upper class European and European American men. As described by Traweek (1988), these men have shaped the notions of science that many of us hold today.

In reading many of the popular histories of science, one would think that women began practicing science only recently. Hubbard shows us, however, that women have made many valuable contributions to science throughout time. Unfortunately, most of these contributions have gone unnoticed. Why?

If we look at the totality of public science, we see that many people are involved, women, minorities and men. If we take a closer look at the positions people hold, we begin to see where differences occur. White men often hold prominent “mental” positions in the hierarchy, are laboratory heads and, therefore, chief “factmakers.” Women and minorities are often relegated to the “manual” jobs. Hubbard explains the differential value of these positions.

For historical reasons, this society values mental labor more highly than manual labor. We often pay more for it and think that it requires more specifically human qualities and therefore is superior. This is a mistake especially in the context of a scientific laboratory, because it means that the laboratory chief-the person “with ideas”-often gets the credit, whereas the laboratory workers-the people who work with their hands (as well as, often, their imaginations)-are the ones who perform the

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Hubbard documents how scientific research itself has been used to justify certain people's positions in the hierarchy. Nineteenth century scientists attempted to prove that women's and minorities' brains were smaller than white men's were. These scientists tried to then show that minorities' and women's mental abilities were inferior to white men's. It seemed natural and appropriate that women and minorities would do the "manual" jobs of science while European and European American men did the important "mental" work.

Like many feminists Hubbard not only calls into question the division of labor in science but also the basic principles of objectivity from which scientists operate. Their definitions of objectivity serve to keep those possessing power in power and to deny others access to science. In traditional science, scientists are objective by supposedly separating themselves from their objects of study. This goal is represented in scientific writing which deletes the scientist as agent in the report. Scientific reports are written as if the work were done "in a vacuum" without the influence of the scientist *himself*. Hubbard states that instead we must completely acknowledge our role and location in the process of science.

Awareness of our subjectivity and context must be part of doing science because there is no way we can eliminate them. We come to the objects we study with our particular personal and social backgrounds and with inevitable interests. Once we acknowledge those, we can try to understand the world, so to speak, from inside instead of pretending to be objective outsiders looking in. (p. 127)

Making our subjectivity and context explicit are beginning steps to Hubbard's summons for a broader science which is inclusive to the voices that have not been recognized previously. There is much to be done in this project. We must go back and

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look at the contributions women have made to science in the past as assistants to men scientists and in the household domain. We must question further why some contributions have been accepted as “science” while others have not. We must recognize science as a political enterprise that serves the interests of a narrow few and work to broaden the experience and knowledge base of science so that it can be done by and serve many others. We must look at alternative models of doing science such as feminist health centers and counseling groups. At the same time we must keep in mind that there is no one perfect model of doing science but multiple, valuable ways that will be inclusive of many people.

“Strong Objectivity”

Sandra Harding (1996) calls for the same critical self reflection advocated by Evelyn Fox Keller and questions standard definitions of objectivity as Ruth Hubbard does. Through standpoint approaches Harding asserts that acknowledgement of the subjects of knowledge will lead to “strong objectivity.”

Strong objectivity requires that the subject of knowledge be placed on the same critical, causal plane as the objects of knowledge. Thus, strong objectivity requires what we can think of as ‘strong reflexivity.’ This is because culturewide (or nearly culturewide) beliefs function as evidence at every stage in scientific inquiry: in the selection of problems, the formation of hypotheses, the design of research (including the organization of research communities), the collection of data, the interpretation and sorting of data, decisions about when to stop research, the way results of research are reported, and so on. The subject of knowledge-the individual and the historically located social community whose unexamined beliefs its members are likely to hold ‘unknowingly,’ so to speak-must be considered as part of the object of knowledge from the perspective of scientific method. (p. 244)

Harding believes that this careful reflexivity must be directed at both scientists and the society from which they draw their values and assumptions. In order to be fully effective, groups who have been marginalized by traditional science must do this

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reflection. Previous notions of *objectivity* by the scientific community are, therefore, too narrow. Scientific goals of logical, rational, value-free and unbiased research aimed at *truth*, in fact, have very different purposes. They merely reflect the assumptions and social values of the scientific community instead of representing the entire human population, world and universe (as they are stated to do). Harding clearly shows the sexist and racist consequences of the community of people who do science. “If the community of ‘qualified’ researchers and critics systematically excludes, for example, all African-Americans and women of all races and if the larger culture is stratified by race and gender and lacks powerful critiques of this stratification, it is not plausible to imagine that racist and sexist interests and values would be identified within a community of scientists composed entirely of people who benefit-intentionally or not-from institutionalized racism and sexism” (p. 245).

Harding also identifies some of the key aspects of the narrow conceptualization of objectivity. She states that objectivity is defined by the justification of research methods. Identifying problems of study is considered outside of the realm of rationality. However, problems defined by scientists and hypotheses to be tested often do not allow for the questioning of sexist and racist assumptions which scientists take for granted in the broader society. This narrow definition of objectivity prevents scientific methods to be used on questions of interest to marginalized groups.

At the same time she believes that objectivity has been defined too broadly. In its ideal form, it should eliminate all social bias. However, Harding contends that social values and interests clearly contribute to the research process. In fact, social values and assumptions that advance democracy have positively contributed to “less partial and distorted beliefs than others.”

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Objectivism has been mystified in our society, and this contributes to its power and “widespread appeal to dominant groups.” It permits scientists to produce findings without accounting for the historical conditioning of that knowledge. Through their narrow definitions of objectivity, scientists have justified their position that the historical shaping of science and the values of society are irrelevant to their work. Harding call for exactly this broadening of scientific study to the subjects involved to produce a “strong objectivity.”

She acknowledges that many feminists and others would like to eliminate the notion of objectivity due to its entrenched rooting in androcentric bias and the harm it has caused marginalized groups. On the other hand, Harding recognizes the contributions that objectivity has made to scientific knowledge and argues for a reconceptualization of the idea rather than its dismissal. By including the subject in the critical purview of science and recognizing the unique position of marginalized groups to critique the subjects and objects of science, we can think about objectivity as “the gap that should exist between how any individual or group wants the world to be and how in fact it is” (p. 247).

The Partiality and Situated Nature of Knowledge

Like Sandra Harding, Donna Haraway (1996) is interested in developing a useful conception of objectivity. Her definition of feminist objectivity is “situated knowledges.” She discusses how our use of technology appears to provide “more” distance from our objects of study. She instead states that objectivity is closer to oneself.

So, not so perversely, objectivity turns out to be about particular and specific embodiment and definitely not about the false vision promising transcendence of all limits and responsibility. The moral is simple: only partial perspective promises objective vision. All Western cultural narratives about objectivity are allegories of the ideologies governing the

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relations of what we call mind and body, distance and responsibility. Feminist objectivity is about limited location and situated knowledge, not about transcendence and splitting of subject and object. It allows us to become answerable for what we learn how to see. (p. 254)

Haraway uses the analogy of photographs to further explain partial perspectives. She imagines seeing a variety of photographs from satellite cameras, cameras that photograph in ways similar to insects' complex eyes, our own eyes, etc. It is only through these multiple photographs that we get a more complete, a more objective view.

As with Harding's development of standpoint approaches, Haraway also believes that the views of the subjugated are the most important perspectives for gaining a more objective understanding of science. She explains her reasoning for the significant value of these perspectives.

The standpoints of the subjugated are not 'innocent' positions. On the contrary, they are preferred because in principle they are least likely to allow denial of the critical and interpretive core of all knowledge. They are knowledgeable of modes of denial through repression, forgetting, and disappearing acts-ways of being nowhere while claiming to see comprehensively. The subjugated have a decent chance to be on to the god trick and all its dazzling-and, therefore, blinding-illuminations. 'Subjugated' standpoints are preferred because they seem to promise more adequate, sustained, objective, transforming accounts of the world. (p. 255)

Haraway does not see the standpoint of subjugated groups as unproblematic, however. She states that we must be careful to not romanticize their views and irresponsibly appropriate them for ourselves.

Haraway claims that the privileging of partial perspective is a workable alternative to the relativism rejected by totalizing, authoritative visions of science. "The alternative to relativism is partial, locatable, critical knowledges sustaining the possibility of webs of connections called solidarity in politics and shared conversations in epistemology" (p. 255-256). She sees relativism and totalization as mirror images of each other. They both

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promise “vision from everywhere and nowhere equally fully” (p. 256). In fact, they allow nothing to be seen well. Only through partial perspectives can there be the “possibility of sustained, rational, objective inquiry” (p. 256).

Haraway further explains how partial, situated knowledges promise more objectivity than the traditional, all encompassing, all-knowing, disembodied form of science.

Situated knowledges are about communities, not about isolated individuals. The only way to find a larger vision is to be somewhere in particular. The science question in feminism is about objectivity as positioned rationality. Its images are not the products of escape and transcendence of limits (the view from above) but the joining of partial views and halting voices into a collective subject position that promises a vision of the means of ongoing finite embodiment, of living within limits and contradictions-of views from somewhere. (p. 259)

She states our goal from this reconceptualization as “better accounts of the world, that is ‘science’” (p. 258).

Feminist and Sociocultural Perspectives on the Social Context of Discourse

Influences of culture, gender and other social factors in classroom discourse have become increasingly important concerns in teaching and research. Feminist and sociocultural researchers, as well as others, have made substantial contributions to these educational domains. In this section I discuss the contributions of a few key authors who provide useful understandings of the social context of discourse as well as new conceptions that may be more inclusive.

Maria Lugones’ work does not directly deal with classrooms, but her development of the concept of playful “world”-travelling allows us to recognize, learn about and value the cultures of students and teachers. “World”-travelling gives us a way to have authentic and meaningful discourse with others who are different from ourselves. Deborah Tannen

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looks at the specific culture of gender and shows how gender is associated with physical alignment and topical cohesion during conversations. Carole Edelsky develops a unique conception of the floor during conversation, a collaboratively developed floor that equalizes the interactions of women and men. Kathleen Weiler documents how feminist teachers acknowledge and include the gender, class and racial subjectivities of students by expanding official classroom discourse. From a sociocultural perspective Sarah Michaels and Mary Catherine O'Connor discuss the multiple discourses children bring with them to school and support a "discourse space" where home-based discourses can be valued and school-based discourses made explicit. These authors together provide diverse perspectives on the importance of the social context of classroom discourse and show ways of broadening traditional school discourses so they may be more inclusive and valuing of all children.

Playful "World"-Travelling

Maria Lugones (1987) has created an intriguing and "playful" invention of "world"-travelling, a concept that allows us to experience the culture of others in ways that are authentic, respectful and fun. Lugones tells us that outsiders must "world"-travel, but she also encourages those in the mainstream to try it as well.

...the outsider has necessarily acquired flexibility in shifting from the mainstream construction of life where she is constructed as an outsider to other constructions of life where she is more or less 'at home.' This flexibility is necessary for the outsider but it can also be willfully exercised by the outsider or by those who are at ease in the mainstream.
(p. 3)

Lugones goes on to say that the practice of "world"-travel requires a great deal of skill. However, outsiders and those in the mainstream have not recognized that skill because racism has a vested interest in devaluing it. Also, outsiders have not fully seen

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the value of “world”-travelling because they have been forced to travel to mainstream worlds that are often hostile. She advises that we “affirm this travelling across ‘worlds’ as partly constitutive of cross-cultural and cross-racial loving” (p. 3-4).

Lugones points out that we have a failure to love when we fail “to identify with another woman, the failure to see oneself in other women who are quite different from oneself” (p. 7). White women, in particular, have failed to love women of color often without seeing the loss to themselves or other women.

Their world [white women’s] and their integrity do not require me at all. There is no sense of self-loss in them for my own lack of solidity. But they rob me of my solidity through indifference, an indifference they can afford and which seems sometimes studied. (p. 7)

Lugones comments that the indifference of white women can lead women of color to seek separatism, to find communities “where our substance is seen and celebrated.” However, she does not see separatism as an answer as many women of color need to work among White/Anglo women. Lugones also finds hope for recognition “among White/Anglo women because many of them have expressed a *general* sense of being pained at their failure of love” (p. 7).

Lugones claims that to have a complete sense of ourselves, we need to identify with others. She provides a way to make that identification through “world”-travelling.

We are fully dependent on each other for the possibility of being understood and without this understanding we are not intelligible, we do not make sense, we are not solid, visible, integrated; we are lacking. So travelling to each other’s “worlds” would enable us to *be* through *loving* each other. (p. 8)

Lugones’ conception of a world is multiple, flexible and dynamic. She cautions against a rigid definition, as she wants to keep the idea open and suggestive.

For something to be a “world” in my sense it has to be inhabited at present by some flesh and blood people. That is why it cannot be a utopia.

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It may also be inhabited by some imaginary people...A "world" in my sense may be an actual society given its dominant culture's description and construction of life, including a construction of the relationships of production, of gender, race, etc. But a "world" can also be such a society given a non-dominant construction, or it can be such a society or *a* society given an idiosyncratic construction. As we will see it is problematic to say that these are all constructions of the same society. But they are different "worlds". (p. 9-10)

Worlds can be big, little, incomplete, traditional or visionary. Inhabitants may not hold or understand the ways they are constructed in different worlds. One can inhabit different worlds at the same time and be different in those worlds.

In order to *be* in different worlds, one must *travel*. Lugones describes "travel" in the following ways.

The shift from being one person to being a different person is what I call "travel". This shift may not be willful or even conscious, and one may be completely unaware of being different than one is in a different "world," and may not recognize that one is in a different "world". Even though the shift can be done willfully, it is not a matter of acting. One does not pose as someone else, one does not pretend to be, for example, someone of a different personality or character or someone who uses space or language differently than the other person. Rather one is someone who has that personality or character or uses space and language in that particular way (p. 11-12).

Lugones gives specific suggestions on how one may be at ease in a "world." Being a fluent speaker in a particular "world" can do this. One may agree with the norms of the "world" and be happy with them. One may be humanly bonded to someone else in that world. One may have a shared history with others in that "world." She states that we may be at ease with parts of a "world" and not at ease with others. One may be more comfortable in particular "worlds" than in others.

To be located in different "worlds" at the same time and to be different in those "worlds" represents the plurality of our selves. Lugones uses these ideas to explain the schizophrenia often felt by women of color as they inhabit various "worlds."

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...I am different persons in different “worlds” and can remember myself in both as I am in the other. I am a plurality of selves. This is to understand my confusion because *it is to come to see it as a piece* with much of the rest of my experience as an outsider in some of the “worlds” that I inhabit and of a piece with significant aspects of the experience of non-dominant people in the “worlds” of their dominators. (p. 14)

Maria Lugones invites us to be playful in worlds that are healthy for us.

Playfulness is, in part, an openness to being a fool, which is a combination of not worrying about competence, not being self-important, not taking norms as sacred and finding ambiguity and double edges a source of wisdom and delight. (p. 17)

Certainly, it is not safe to be playful in all worlds, but playfulness allows us a creative, imaginative and enjoyable way to reflect and understand ourselves and others in particular “worlds.”

Lugones’ conception of playful “world”-travelling permits us to richly experience and authentically identify with others unlike ourselves, “...by travelling to their ‘world’ we can understand *what it is to be them and what it is to be ourselves in their eyes*” (p. 17).

Gender Alignment and Cohesion in Conversational Coherence

As Maria Lugones helps us to better understand the place of culture in our discourse through her descriptions of the experiences of women of color in mainstream society, Deborah Tannen examines a particular culture, the culture of gender in communication. Tannen (1994) and others suggest that women and men comprise their own cultural groups. Since our early socialization occurs in same-gender groups, we have established gender-associated communication styles.

In the study discussed here, Tannen looked at two features of conversational coherence which have gender associations, physical alignment and topical cohesion. She defined the characteristics in the following way.

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By *physical alignment* I mean the ways that speakers position their heads and bodies in relation to each other, including eye gaze. With Schifffrin (1988), I take “topic” to be, simply, “what speakers talk about.” *Topical cohesion* then refers to how speakers introduce and develop topics in relation to their own and others’ prior and projected talk. (p. 86)

In twenty-minute videotape segments, Tannen observed the physical alignment and topical cohesion of eight pairs of same gender friends in the following age groups: second graders, sixth graders, tenth graders and 25-year-olds. The pairs were asked to talk about something serious.

For physical alignment Tannen found definite gender associations in each of the four age groups. The girls and women always sat very close to each other with their bodies aligned facing each other. They sat very still, gazed directly at each other with occasional glances away and sometimes touched each other. The boys and men in every age group, on the other hand, sat with their chairs angled to each other. They rarely looked at each other with their gazes focused mainly elsewhere in the room. The young boys were restless in their chairs. The tenth-grade boys sprawled in their chairs, and the older men sat still but parallel to each other rather than head on.

Tannen describes specific features of each age group. Here I report the second-grade traits, as this dissertation focuses on that age group. At the beginning of the session, one girl sat at the edge of her seat while the second girl sat back. Then the second girl moved forward, and the first girl sat back still keeping the distance between them small. At the end of the time, both girls were sitting at the edges of their seats. For the majority of the session the girls looked directly at each other almost “nose to nose.” Occasionally, their heads would turn away as they thought of something to say, but their bodies always remained aligned facing each other.

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The second-grade boys presented a contrasting picture. Their chairs were at an angle more distant than the girls' chairs had been. They rarely looked at each other, and their gazes wandered around the room. They squirmed in their chairs, would get up and sit down again, would hit the chair arms, kick their feet, point to things around the room and make faces at the camera.

The findings for topical cohesion parallel those of physical alignment. The girls' and women's talk was tightly focused, while the boys' and men's talk was diffuse. The girls and women had no trouble finding topics and talked in-depth about a few areas. The boys and men had great difficulty coming up with topics except for the tenth-grade boys. The younger boys talked about many topics briefly, while the men talked about only a few topics on an abstract level. The choice of topics was different by gender as well. The boys and men often used objects in the room for topics, but the girls and women rarely did that. Violence was occasionally mentioned in the boys' talk but never in the girls'. The girls, however, were concerned with avoiding anger and disagreement.

In looking more closely at the second-graders, Tannen found that the girls immediately found a topic to discuss. They told stories to each other. When reminded to talk about something serious, they decided to tell stories of various illnesses. They followed a particular speech pattern with a "drawn-out rising intonation" in the beginning much like Michaels and Cook-Gumperz (1979) descriptions of kindergarten "sharing time" narratives. There was cohesion in that one story of an illness prompted another story of sickness from the other girl. The girls seemed quite comfortable with their topics and the activity of talking, in general.

The second-grade boys again responded quite differently from the girls. They seemed quite uncomfortable with the instructions of talking and immediately tried to

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think of something to do. They briefly discussed a number of topics and engaged in physical activities such as playing patty-cake and making faces at each other. At one point one of the boys took on the role of the interviewer suggesting that the activity of just talking together was unnatural. His view of sitting down and talking seemed to require something like an interview. Of the topics addressed, the boys talked generally about how each one was feeling and also discussed school and sports. The other male groups discussed these same topics.

Tannen summarizes her findings by stating that girls and women and boys and men display their involvement in conversations in very different ways. These “gender differences can be understood as cultural differences” and may help explain the frustration we sometimes feel in mixed gender groupings.

It is likely that one source of the most frequent complaint by women about their relationships with men—that men do not listen to them—issues from differences demonstrated by this study: Perhaps the men do not face them head on and maintain eye contact, do not pursue a topic at as great a length as women do, and respond to concerns either by raising a topic of their own concern or by denying or belittling the basis for the woman’s concern. If cross-cultural differences are at play, then these patterns of conversational involvement do not indicate lack of listenership but rather different norms for establishing and displaying conversational involvement. (p. 128)

Collaborative Development of the Conversational Floor

Carole Edelsky has also investigated gender differences in conversation. In one study (1993), she attempted to examine the relationship between gender and language in faculty committee meetings. However, she found that it was not easy to determine the turn taking mechanisms. She decided that she first needed to more fully develop the concept of “the floor.”

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Much of the previous work in conversation was based on the assumption that speakers talk in turns one-at-a-time. While this assumption holds for certain conversational situations such as dyad talk, there are many other examples of “naturally occurring simultaneous talk.”

Another complexity is in defining a turn itself. The trouble with standard definitions such as solo talk is that they often do not represent the speaker’s intentions of what constitutes a turn or a participant’s experience of a turn. Edelsky states that much of the research on conversational turns and floor has focused on the technical aspects of these concepts and presumes “that the primary goal in conversation is to conduct the event rather than to make meanings (Cicourel, n.d.)” (p. 204).

Little work has been done explicitly with the concept of “the floor.” As with turns it has been defined in various ways including “a speaker, a turn, and control over part of a conversation.” Edelsky acknowledges that often there may be a lone speaker taking a turn and having the floor concurrently. However, if we only use this conception of turn and floor, we may not consider multiple topics and simultaneous speakers as part of the conversation in retrospect. She warns that by not separately considering turn from floor, we ignore other ways of possessing the floor.

She attempts to clarify her meaning by explicitly defining turn and floor.

I define turn as *an on-record “speaking”* (which may include nonverbal activities) *behind which lies an intention to convey a message that is both referential and functional* (p. 207).

Not all talk constitutes a turn. Talk that is off the record and may be stated only to a few people is a “side comment.” Additionally, talk that provides feedback but not referential messages are identified as “encouragers”.

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The floor is defined as *the acknowledged what's-going-on within a psychological time/space*. What's going on can be the development of a topic or a function (teasing, soliciting a response, etc.) or an interaction of the two. It can be developed or controlled by one person at a time or by several simultaneously or in quick succession. It is official or acknowledged in that, if questioned, participants could describe what's going on as "he's talking about grades" or "she's making a suggestion" or "we're all answering her." (p. 209)

There can be "non-floor-holding turns," and one can hold the floor without taking a turn. Non-floor-holding turns may "have both propositional and functional content (not merely encouragers), and are therefore turns but which do not constitute the official what's-going-on" (p. 209). Examples of these turns include clarifying questions and additions of details to the floor-holder's report.

Edelsky also gives an example of holding the floor without taking a turn. At one meeting she was giving a report on students who needed help with writing. During the report she silently counted student papers in various categories. Others made comments, but Edelsky retained the floor for her report.

Turns can also jointly build a floor. This perception led Edelsky to define "collaboratively developed floors," floors which are constructed by the turns of multiple speakers. She characterizes three types of floors.

...there were frequent stretches of talk, lasting from 1.8 to 45.9 seconds in the first meeting at least, for which I could not determine who had the floor. I referred to these as collaboratively developed floors, as opposed to singly developed floors which were held primarily by one person at a time. There were two main types of collaborative floors: seeming free-for-alls and, more frequently, cases of several people being "on the same wavelength"...it [free-for-all] shows much simultaneity, joint building of an answer to a question, collaboration on developing ideas...and laughter. (p. 196)

Other collaborative stretches of talk ["on the same wavelength"], however, seemed more "orderly" and less "noisy"; yet it still was not possible to say that any one person had the floor. Rather, the impression was that several people were "on the same wavelength," even if in a

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sequence, sharing in the creation of an idea or a function (joking, suggesting, etc.). (p. 197)

Sometimes, being on the same wavelength was inferred from long overlapping turns which each simultaneously developed the same entire idea or answered the same question...and where neither turn yielded to the other, as though in a fugue or a variation on a theme. (p. 198)

There were other times...when this collaboration was achieved both through attention to the same function (answering) and topic and also through matching and marked rhythm and intonation. (p. 199)

Elsewhere, joint development of meaning and/or function was accomplished by individuals contributing pieces of one idea. There were even same-wavelength episodes where two or more people built one hedge, aborting their turns on their own, uninterrupted, and unoverlapped. (p. 200)

Edelsky found gender patterns associated with the floors. Men participated more than women in singly developed floors. Men talked less in collaboratively developed floors than they did in singly developed floors and sometimes talked less than the women in collaboratively developed floors. In terms of turn length, men talked one and a quarter to four times as long as women did in singly developed floors. However, women and men talked of equal duration in collaborative floors.

There was also a wider use of different language functions in the collaboratively developed floors. The male chair often used questioning in singly developed floors, while women primarily were the questioners in collaboratively developed floors. The language functions typically associated with the "male domain" such as joking, arguing and directing responses were used more often by men in singly developed floors but more often by women in collaborative floors.

The collaboratively developed floors seemed to offer a more equal playing ground for women and men. Edelsky comments on this discrepancy between the floors.

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Singly developed floors, characterized by monologues, single party control, and hierarchical interaction where turn takers stand out from non-turn takers and floors are won or lost, share features with other contexts in which women have learned they had best not assert themselves. Collaborative floors, however, are inherently more informal, cooperative ventures which provided both a cover of “anonymity” for assertive language use and a comfortable backdrop against which women can display a fuller range of language ability. (p. 221)

Certainly collaboratively developed floors extend benefits for both women and men. The site provides “an opportunity for experiencing high involvement, synergistic, solidarity-building interaction” (p. 221). The concept offers exciting possibilities for developing gender equity in communication.

Expansion of Classroom Discourse

Kathleen Weiler (1988) addresses the complexities of gender, race and class in communication as they are expressed by students and teachers. She explains that we bring differing and sometimes conflicting ideologies and experiences of “domination, submission, oppression and privilege” to the classroom. By recognizing and discussing these various dimensions of ourselves within school, we can “expand the discourse” to be legitimating of more students’ identities.

Weiler claims that we need to see others and ourselves as “multi-layered subjects.”

The concept of “multi-layered subjects” points to the sometimes contradictory nature of this “infinity of traces”: that the power of gender, class, or race may be employed to counter oppression suffered through another aspect of our being. These are the contradictions and tensions between overlapping forms of oppression and forms of power that face feminist teachers in multicultural public school classrooms (p. 126).

Weiler draws on the work of Paulo Freire in stating that teachers and students need to address the complex, contradictory and conflicting nature of their subjectivities through dialogue. She is quick to point out that this dialogue is a difficult process. A

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white, middle class, feminist teacher may find her subjectivities in validation of some students yet in opposition to the experiences of other students. White, middle class girls may find a teacher's work to identify and oppose sexism affirming to their subjectivities. However, as a white teacher "she may symbolize racist oppression to her black students."

In her work with feminist teachers, Weiler found that they were very aware of sexism in relation to their own subjectivities, as well as being conscious and sensitive to the race and class identities of their students.

...the teachers talked of raising questions and making the students more self-conscious about racism and sexism while respecting their own cultural worlds. They defined their work as providing a place where students could interrogate their own accepted beliefs and identities; they defined teaching not as the transmission of a static "knowledge," what Freire refers to as banking education, but as an expansion of accepted discourse both about society as a whole and about the subjective experiences of students. (p. 127)

Weiler states that classroom discourse is not neutral territory. Students and teachers create meaning that "is always situated in the context of a socially and historically defined present" (p. 128-129). Discourse is used by both teachers and students "to assert their own power and to try to create sense for themselves out of a complex social setting" (p. 129). Typically, discourse is dominated by teachers in their establishment of the curriculum and norms of the classroom. However, students also participate and control part of the discourse of the classroom. Students' intentions may not fit with teachers' intentions or the official intentions of school. Teachers, therefore, need to make students' intentions a legitimate part of the classroom discourse. The task is made difficult not only by the possibly conflicting intentions of students and teachers but also by conflicts among different students. Subjectivities are constantly changing and "being redefined as meaning is asserted, contested, affirmed, or denied" (p. 129).

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The teachers whom Weiler worked with attempted to recognize their students' subjectivities as well as their own in two ways.

First, they expand the limits of discourse, by directly addressing the forces that shape their students' lives. As teachers, within the scope of the curriculum and the structure of the school, they select topics for discussion and study, but they also attempt to legitimize their students' voices by acknowledging their students' own experiences and by calling for their students' own narratives. They frequently comment directly on classroom interaction and attempt to create relationships within the class that challenge accepted behavior and attitudes of men and women. Second, and related to the expansion of the discourse, is their own presentation of themselves as gendered subjects with a personal perspective on issues of gender and race. They are overtly political in their presentation and both [feminist teacher approaches] will use personal anecdotes and will challenge and engage students on these topics. Thus they reveal their own subjectivity and interests, while at the same time within certain limits legitimating the subjectivity of their students. (p. 131)

One of the teachers used small group work as a way to break down the teacher-centered structure of the classroom, but she also used this approach to challenge accepted roles of girls and boys in classroom organization. Often, boys will either dominate small group discussions or "opt out" leaving the girls to fulfill the requirements of the assignment. This teacher addressed these problems by having girls be spokespersons and boys be secretaries in the groups. The teacher often came in conflict with the boys who saw her favoring the girls or causing reverse discrimination. However, she made explicit her goal as "she forces students out of accepted relationships and thus calls into question the dominate/subordinate gender relationships to which they are accustomed" (p. 133).

Weiler comments that the feminist teachers who do call into question the traditional beliefs about gender are not imposing their meaning any more than traditional teachers who ask students to accept the authority of the teacher and the status quo. "In all these classrooms, meaning is negotiated and contested by teachers and students with very different class, gender, and race histories and relationships" (p. 137). Conflicts between

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teachers and students occur in all classrooms. The feminist teachers choose to acknowledge the conflicts including gender, race and class subjectivities. Only then can they be “addressed and transformed.”

Learning Science through Multiple Discourses

Sarah Michaels and Mary Catherine O'Connor (1990) address the issue of classroom discourse from a sociocultural perspective. They propose a need to recognize and use the multiple discourses in which students participate. They use James Gee's (1989) formal definition of discourse as an “identity kit”:

a socially accepted association among ways of using language, of thinking, acting, and of valuing that can be used to identify oneself as a member of a socially, meaningful group or “social network.” (p. 1)

Michaels and O'Connor state that we become literate in a particular domain by “learning a specific discourse-particular ways of thinking, acting and valuing” (p. 11). Since there are multiple discourses that we may operate within, literacy becomes a “plural notion.” Students come to school having learned a particular discourse from their home. Home discourses differ among cultural groups, and some are closer to traditional school-based discourses than others. School failure then with poor and minority children may be viewed as a failure to help these students learn the discourse of school.

Michaels and O'Connor give an example of Elizabeth, a working class Haitian girl, who did not give a *scientifically* correct answer as to why a particular placement of weights made a scale balance. Elizabeth knew how to place the weights so that the scale would balance, but when asked why, she said she figured it out by thinking in her head. Sarah Michaels interviewed Elizabeth after the lesson to probe her understanding.

She [Elizabeth] interpreted Michaels' and the teacher's “why questions” as asking her about the status of her knowledge and how she came by it—did she guess, was she persuaded by her classmates, or did she figure it

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out for herself? In as many different ways as she could, Elizabeth was trying to explain that she had figured it out for herself. However, in the discourse of school science, in order to count as having figured something out, you have to make the reasoning explicit. You have to give the proof, the theory, the model or mathematical reasoning that explains the phenomenon in question. (p. 17)

While this reasoning seems obvious to those who control the discourse of science and many middle class children, it is not so obvious to other children. The practices of science that we take for granted need to be made explicit so that more children can acquire this discourse. Teachers need to “introduce and enculturate students into these school-based discourses, without denigrating their culturally specific values and ways of using language” (p. 18).

Michaels and O'Connor summarize strategies from three successful school projects that helped students acquire school-based discourses.

1. In each case, a discourse space is created whereby divergent viewpoints, experiences, and ways of speaking come into contact in a structured, teacher-orchestrated dialogue. As students discuss, debate, question, and collaboratively carry out real tasks in a given domain, they gain mastery over content, concepts, strategies, and ways of speaking. The discourse becomes their own.
2. Teachers allow and in fact require the students to generate knowledge on their own and to play the roles of questioner, critic, and expert. The typical relationships between teacher and students with respect to authority and control over knowledge is altered in these discourse spaces. At the same time, teachers participate in the discourse, modeling modes of inquiry and ways of speaking.
3. There is explicit talk about talk, and explicit, teacher scaffolded practicing of the discourse. (p. 22-23)

Michaels and O'Connor's development of a *discourse space* in classrooms allows for the recognition and acknowledgement of the multiple discourses students bring to school. It also provides the explicit scaffolding necessary to help students acquire new school-based discourses that may be very different from their own.

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Comparison of Perspectives and Relevance to Elementary Science Classrooms

Feminist critiques of science and the feminist and sociocultural work on the social context of discourse are complementary perspectives that have important implications for elementary science classrooms. Together they call for a broader vision of science that recognizes the ways of knowing of all people. The use of these ideas in schools will help more children, especially girls and minorities, to be comfortable participants and valued creators of science.

Exclusive White Male Conceptions of Science and Discourse

Feminist critiques of science show us that Western science, the public science with which most of us are familiar, is a field that has been narrowly defined by European and European American men. While maintaining a ruse of universality, this science instead has been one created largely to serve the purposes and perpetuate the interests of white men. Evelyn Fox Keller (1996) and Ruth Hubbard (1989) show us how many of the features associated with science such as power, control, domination, autonomy and objectivity are traits also associated with men and traits that have excluded or marginalized women's and minorities' contributions from science. Sharon Traweek's ethnographic study (1988) of the particle physics community reveals how many of the historically male features of science still predominate in this and other scientific communities.

Likewise, the research on gender and culture in discourse also demonstrates the limitations and white male nature of traditional discourse. Maria Lugones (1987) shows us how racism restricts and devalues identification with other cultures for white women (and white men). Deborah Tannen (1994) demonstrates that women and men have different conversational styles and give different communication clues. As a specific

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example in conversation, Carole Edelsky (1993) documents male domination of singly developed floors. Often, the conversational strategies used by men have dominated and limited public discourse. Kathleen Weiler (1988) discusses the traditional teacher domination of classroom discourse that is restrictive, as it does not legitimately recognize the intentions of students. Sarah Michaels and Mary Catherine O'Connor (1990) reveal how dominant school-based discourse is alienating and confusing to many students.

Alternative Visions of a Broader, Inclusive Science with Multiple Discourses

Feminist critics offer possibilities for changing science in ways that will make it more inclusive and valuing of others' experiences. Keller describes how Barbara McClintock and other scientists prefer to have a "conversation with nature" rather than "control of nature." These scientists provide interactional and nonhierarchical explanations of the natural phenomena they observe. Sandra Harding (1996) and Donna Haraway (1996) call for a reconceptualization of objectivity in science that acknowledges the subject's relation to the object and the partial situated nature of knowledge. Hubbard reminds us that we should not look for a perfect model of science and instead recognize many valid ways of doing science.

The plurality theme of science developed by many feminist critics extends to culture, gender and discourse as well. Lugones tells us how "world"-travelling to other cultures shows us the plurality of our own selves and allows us to be more complete. Tannen explores the multiple ways people have of interacting that are often influenced by their gender. Edelsky provides multiple conceptions of "the floor" showing possibilities for equitable communication by gender in collaboratively developed floors. Weiler sees students as "multi-layered subjects" whose gender, race and class subjectivities need to be

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legitimized by “expanding the discourse.” Michaels and O’Connor demonstrate that literacy is a plural notion involving the use of multiple discourses.

Gender and Cultural Inclusion within the Elementary Science Classroom

The ideas developed by feminist scientists and feminist and sociocultural researchers studying the social context of discourse can help make elementary science classrooms more inclusive. Traditional features of power, control, autonomy, universality, objectivity and value-free truth in science can be challenged with feminist conceptions of a plural, subjective, culturally based, value laden, human, partial and situated science. Students can learn about a wider set of scientists than those aloof, white men that are traditionally portrayed in textbooks. Additionally, the characteristics of scientists may be broadened beyond the aggressive, competitive, individualistic, elitist traits of particle physicists to include less well known cooperative, personal, nonhierarchical characteristics. Students may learn to value more histories of science that include women and minorities rather than the brief side notes of famous white men in their textbooks. Students can be taught alternative models of science besides the “scientific method” and recognize that there are many valid ways of doing science.

A key aspect of both the feminist critiques of science and the discourse literature is the acknowledgment of the multiple dimensions of the self that are integral to doing and talking about science. Hubbard and Harding claim that we must recognize our subjectivity and context in science rather than treating our work as universal, objective explanations of natural phenomena free of the influence of scientists themselves. Children also can show their subjectivities in scientific investigations through their talk and writing.

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The feminist critiques of science and gender and culture in discourse literature also provide ways to welcome and value the experiences of all children. Feminist calls for a plural science allow students' multiple ways of knowing that can be recognized and utilized in the classroom. Lugones gives us a way to affirm difference and identify with others through "world"-travelling. Tannen's work invites us to use multiple communication styles in science from the abstract ways that men often talk to the storytelling approaches women frequently use. Edelsky's development of collaborative floors provides us with alternative ways to structure talk in classrooms that make communication more equitable by gender. Likewise, Weiler's discussion of small group strategies permits a move towards a more student-centered classroom, which also provides opportunities to challenge accepted gender roles. Michaels and O'Connor recommend that we allow students to work within a *discourse space*, a place where scientific discourse is explicitly taught while home-based discourses are also utilized and valued.

Relation of Feminist Science and the Social Context of Discourse to Other Research in Science Education

The work of feminist scientists as well as feminist and sociocultural research on the social context of discourse provides complementary yet innovative perspectives to other research traditions in science education. One important area in science education has been conceptual change research (e.g., Bishop & Anderson, 1990; Lee, Eichinger, Anderson, Berkheimer & Blakeslee, 1993; Smith, 1990; Smith & Anderson, 1984; Strike & Posner, 1992). This work was strongly shaped by Posner, Strike, Hewson and Gertzog (1982), who developed a theory stating that students tightly hold on to intuitive, everyday ideas about science. Teachers need to explicitly address these naive conceptions of

students and demonstrate the power and fruitfulness of scientific conceptions. The feminist and sociocultural work that I reference here agrees with the importance of learning about students' everyday notions of science. Rather than replacing their notions with traditional scientific ideas as conceptual change promotes, however, these authors would encourage the explicit learning of many scientific ideas, critiquing those ideas and also valuing students' intuitive perceptions.

Constructivism is currently the most prominent research perspective in science education (e.g., Cobern, 1998; Peasley, 1996; Staver, 1998). This research is based on the assumption that students actively construct their own knowledge. Shymansky and Kyle (1992) state that this perspective underlies many of the current reform movements in science education such as the Project 2061 initiative (AAAS, 1989). Again, feminist and sociocultural perspectives are in agreement with this assumption but would also ask that an acknowledgement of gender, culture and class along with critiques of societal dominance and oppression should be explicit parts of constructivist learning.

Feminist (e.g., Barton, 1998; Bianchini, Cavazos & Helms, 2000; Howes, 1998; Whitten & Burciaga, 2000) and sociocultural studies (e.g., Anderson, Holland & Palincsar, 1995; Cunningham & Helms, 1998; Kelly & Crawford, 1996) are also gaining more prominence in science education on their own. Michael O'Loughlin (1992) along with others proposed that science education look beyond the innocence of constructivism to deal with the "subjectivity of the learner and the socially and historically situated nature of knowing" (p. 791). Certainly the authors in this review share this position. Important work has also been done by Rosebery, Warren and Conant (1990) on the relevance of culture to students' science learning. Along with Michaels and O'Connor (1990),

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researchers such as Lemke (1990) have done detailed studies revealing the specific nature of scientific discourse.

Science education researchers are beginning to connect the feminist critiques of science with classroom contexts. Roychoudhury, Tippins, and Nichols (1995) propose that feminist critiques be combined with constructivist teaching to provide gender-inclusive science classrooms. The Women's Issues in Science Education group at Michigan State University (Barton, Cavazos, Hazelwood, Howes, Kurth, Richmond, Roth & Smith, 1995; Hazelwood, Howes, Kurth, Richmond, & Roth, 1996) has drawn on feminist critiques to explore their own subjectivities in relation to science and their students.

By linking the feminist critiques of science with literature about the social context of discourse, we can learn new insights into the nature of scientific discourse. With a critical eye, we can more fully understand how scientific discourse has excluded women and minorities and find approaches to broaden the discourse so that our gender, culture and class subjectivities can be legitimately acknowledged.

Conceptual Focus on Knowledge, Language and Subjectivities within a Discourse Community

The preceding theoretical frameworks of feminist critiques of science and sociocultural literature about the social context of discourse shape the research in this study. By expanding the focus of research from students' interactions with scientific content to the larger community within which students learn science, we must concern ourselves with many more factors: the environment in which students learn, the gender, class and cultural background of students, the language students use, interactions among students, etc.

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In order to examine this larger context of school science, I considered three specific constructs located within the framework of discourse: knowledge, language and subjectivities. Kathleen Weiler (1997) highlights and defines these three concepts as key in her work in feminist theory.

By knowledge I refer to the debate about universal vs. particular truth claims and the nature of historical evidence, the question of what exactly are our sources of understanding the past; by language, the question of discourse and its relationship to experience as the source of our knowledge of the past; and by subjectivity, the question of essence and identity. (p. 638)

Weiler locates these concepts in her historical research of women teachers. However, these theoretical areas have relevance more broadly and seem particularly suited to this study of elementary science discourse. All three constructs are key, intertwined components of classroom discourse. While the term *discourse* has taken on multiple meanings, I use Gee's (1991) broad definition of discourse as an *identity kit* which embodies knowledge, language and subjectivities expressed in thought, talk, writing and nonverbal gestures. Gee specifically defines a discourse as

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. (p. 3)

These authors have enriched my understanding of the nature of science and the social context of discourse in science classrooms and provided a foundation for the work in this study. Further elaboration of relevant research from these theoretical frameworks precedes each analysis.

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Chapter 3

GENERAL RESEARCH METHODOLOGY

Introduction

This chapter provides an overview of the research methodology used in this study. I used interpretive methods to examine the norms of an elementary science discourse community and to elucidate certain features of knowledge, language and subjectivities in students' talk, writing and drawing. This research took place in two first-second and second grade classrooms in a culturally diverse professional development school named Spring Valley Professional Development School (pseudonym). I chose to study both the first-second and second grade classrooms because the teachers, Mrs. G and Mr. K, collaboratively taught science together as part of their professional development work. A detailed description of the classroom setting is given in the next chapter. A description of the research objectives, general methodology, data collection and analyses used in this study follows.

Research Objectives

I began the study by focusing on students' interactions in science circle conversations. My initial research objective was to document students' use of oral discourse components, conversational moves that were created to facilitate science discussions and were part of the entire school's multi-year professional development in science and literacy. All teachers in the school utilized the oral discourse components in science discussions in their respective classrooms. As part of their professional development work, Mr. K and Mrs. G created a unique conversational format in which

the entire class sat in a circle on the floor and discussed a science statement or question using the oral discourse components of *I agree* or *I disagree* to frame their contributions.

As I was observing students' use of the oral discourse components, I noted many other interesting features of the conversations that I wished to study further. One key characteristic of the conversations was that they were largely student run with only occasional management by the teachers. I became interested in how the teachers and students developed student ownership of the talk as I had not previously observed this type of dynamic in a whole class setting. At the same time, other substantive features of the conversations drew my attention. Students' contributions were varied, and the flow of the conversations was complex. I attempted to determine patterns of knowledge and language use in the intricate interactions of the students. I also wanted to understand more about the context surrounding the conversations and so enlarged my focus to study more of the science instruction in the classroom including small group activities and journal writing. Journal writing proved a rich source for the study of students' personal expressions in science.

A general description of the relevant facets of an interpretive approach along with their particular application to this study follows. Specific methodological details for each analysis are given in "methods" sections in the beginning of chapters 4-7.

Interpretive Approach

The basic research approach in this study was interpretive, defined by Frederick Erickson (1986) as "interest in human meaning in social life and its elucidation and exposition" (p. 119). Interpretive research studies people in their natural environments and asks the basic question, "What is happening here?" (Erickson, 1986, p. 121).

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Erickson (1986) describes the key features of interpretive theory and method as used in his own work:

In substance, my work is an attempt to combine close analysis of fine details of behavior and meaning in everyday social interaction with analysis of the wider societal context – the field of broader social influences – within which the face-to-face interaction takes place. In method, my work is an attempt to be empirical without being positivist; to be rigorous and systematic in investigating the slippery phenomena of everyday interaction and its connections, through the medium of subjective meaning, with the wider social world. (p. 120)

Many other investigators call this research approach qualitative. “Interpretive” is a more appropriate designation for this work as descriptive statistics were used in the study to confirm and elaborate qualitative patterns. Despite the differences in nomenclature, most qualitative researchers (Denzin & Lincoln, 1994; Metz, 2000; Miles & Huberman, 1994; Strauss & Corbin, 1998) agree on a general definition of the field similar to Erickson. Denzin and Lincoln (1994) additionally emphasize the use of multiple “interconnected methods” which were used in this study.

Data was collected largely by ethnographic methods. Hammersley and Atkinson (1983) define ethnography as a social science method in which the “ethnographer participates, overtly or covertly, in people’s daily lives for an extended period of time, watching what happens, listening to what is said, asking questions; in fact collecting whatever data are available to throw light on the issues with which he or she is concerned” (p. 2). During fieldwork the researcher carefully records direct observations of people and their actions and tries to make sense of what is happening from the participants’ perspectives. The researcher further attempts to understand the setting through other extensive data sources including interviews with participants, written records and other artifacts (Erickson, 1986; Hammersley & Atkinson, 1983;

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Spindler & Hammond, 2000). Hammersley and Atkinson (1994) summarize the common features of ethnographic research:

- a strong emphasis on exploring the nature of particular social phenomena, rather than setting out to test hypotheses about them
- a tendency to work primarily with “unstructured” data, that is, data that have not been coded at the point of data collection in terms of a closed set of analytic categories
- investigation of a small number of cases, perhaps just one case, in detail
- analysis of data that involves explicit interpretation of the meanings and functions of human actions, the product of which mainly takes the form of verbal descriptions and explanations, with quantification and statistical analysis playing a subordinate role at most (p. 248)

I then followed basic methods of analysis in interpretive or qualitative research including the organization of data, determination of patterns and development of general theories (Denzin & Lincoln, 1994; Erickson, 1986; LeCompte, 2000; Miles & Huberman, 1994). Strauss and Corbin (1998) concisely explain these main steps of data analysis using the terms “describing, conceptual ordering and theorizing”:

In brief, *describing* is depicting, telling a story, sometimes a very graphic and detailed one, without stepping back to interpret events or explain why certain events occurred and not others. *Conceptual ordering* is classifying events and objects along various explicitly stated dimensions, without necessarily relating the classifications to each other to form an overarching explanatory scheme. *Theorizing* is the act of **constructing** (we emphasize this verb as well) from data an explanatory scheme that systematically integrates various concepts through statements of relationship. A theory does more than provide understanding or paint a vivid picture. It enables users to explain and predict events, thereby providing guides to action. (p. 25)

When formulating patterns and theories, a central tenet of interpretive analysis is triangulation, the use of multiple data sources or perspectives to support findings (Denzin & Lincoln, 1994; Hammersley & Atkinson, 1983; LeCompte, 2000; Metz, 2000).

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I elaborated on the above procedures with particular strategies that provided more refined interpretations of the data. Specific strategies included case study, discourse analysis, aspects of feminist methodology and descriptive statistics, which are described below.

Yin (1994) defines a case study as an “empirical inquiry” which

- investigates a contemporary phenomenon within its real-life context, especially when
- the boundaries between phenomena and context are not clearly evident. (p. 13)

Stake (1994) uses a somewhat different definition considering a case to be a “choice of object to be studied” (p. 236) rather than a particular methodology. Both Yin (1994) and Stake (1994) agree that the goal of a case study is careful analysis of a particular phenomenon or object leading to generalized understandings. For this research I conducted case studies of new students in order to understand the norms and other features of the classroom discourse communities.

I used discourse analysis (Florio-Ruane, 1987; Stubbs, 1983) to better understand the complexities of students’ oral and written language in their science conversations and journals. Stubbs (1983) loosely defines discourse analysis as “attempts to study the organization of language above the sentence or above the clause, and therefore to study larger linguistic units, such as conversational exchanges or written texts. It follows that discourse analysis is also concerned with language in use in social contexts, and in particular with interaction or dialogue between speakers” (p. 1). Discourse analysis provided detailed interpretations of certain knowledge and language features in the students’ science talk and writing.

I also drew on particular aspects of feminist methodology for data analysis. Feminist methodology is a complex, vast research field still under debate within the feminist community. Sandra Harding (1987) explains some of the difficulties in defining a single feminist method:

One reason it is difficult to find a satisfactory answer to questions about a distinctive feminist method is that discussions of method (techniques for gathering evidence) and methodology (a theory and analysis of how research should proceed) have been intertwined with each other and with epistemological issues (issues about an adequate theory of knowledge or justificatory strategy) in both the traditional and feminist discourses. This claim is a complex one and we shall sort out its components. But the point here is simply that “method” is often used to refer to all three aspects of research. Consequently, it is not at all clear what one is supposed to be looking for when trying to identify a distinctive “feminist method of research”. This lack of clarity permits critics to avoid facing up to what *is* distinctive about the best feminist social inquiry. It also makes it difficult to recognize what one must do to advance feminist inquiry. (p. 2)

Despite the ongoing evolution of the field, certain common methodological features are often found in feminist research studies. These include attention to subjectivity (Oleson, 1994; Westkott, 1990; Acker, Barry & Esseswald, 1991), exploration of the relationship between the researcher and researched (Anderson, Armitage, Jack & Wittner, 1990; Mies, 1991), reflexivity (Pugh, 1990; Fonow & Cook, 1991), consideration of gender, culture and class (Cannon, Higginbotham & Leung, 1991; Griffiths, 1990) and consciousness raising and emancipation (Lather, 1991; Fonow & Cook, 1991). In this study I considered subjectivities as the main focus of analysis in the content of students’ science journals. Gender was also considered in each of the analyses. I was interested in the roles of culture and class as well, but these features were much more complex and did not provide clear, substantiated findings.

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Finally, for each of the knowledge, language and subjectivities analyses, I prepared frequency counts of particular features in students' talk and writing. The frequency counts enabled me to confirm qualitative patterns and to more precisely determine trends in the categories of gender, science topic and time of year. While the term qualitative may imply research without a quantitative component, many qualitative researchers including qualitative methodologists (Miles & Huberman, 1994; Strauss & Corbin, 1998), feminists (Farran, 1990; Jayaratne & Stewart, 1991) and linguists (Heath, 2000; Stubbs, 1983) recommend the use of quantitative measures when appropriate to support qualitative findings.

Data Collection

I observed and collected science class data in two first-second and second grade classrooms in Spring Valley Professional Development School (pseudonym) during the 1995-96 and 1996-97 school years. During the first year of data collection, I focused on science circle conversations as my principal interest was documenting students' use of oral discourse components. Circle conversations typically occurred on Friday mornings for 15-30 minutes in each classroom. To place the conversations within a broader science context, I also observed daily whole class science instruction and discussion, small group investigations and journal writing for approximately monthly periods at the beginning, middle and end of the year. In each classroom science instruction occurred each week for two to three approximately one hour periods in addition to the Friday morning circle conversations. During the second year I enlarged my focus to study all of the science interactions on a regular basis. Because of altered procedures delaying permission from the school administration, however, I began

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observations in mid-November for the second year. A listing with brief descriptions of videotapes made for both years is provided in Appendix A.

Collected data included observations and documentation of classroom interactions, student journals, student and teacher interviews and field notes. The collection of specific data forms is described below.

Classroom Interactions

I made video and audio recordings of all types of science interactions in the classrooms including whole class science instruction and discussion, small group science investigations, individual student journal writing and circle conversations. I usually videotaped each science interaction with two cameras. During whole class teacher instruction and accompanying student discussion, one camera was used to focus on the speaker with occasional pans of the entire group. During small group investigations and journal writing, each of the two cameras was focused on one small group of students. In the circle conversations one camera was stationary to capture the entire group of students from which I could document which students attempted to participate and which did not. I also used a roving camera to concentrate on the substantive content and conversational style of individuals sharing their ideas.

Student Journals

Student journal writing was videotaped for documentation of student interaction and other behaviors during journal writing. In addition, I photocopied each student journal in both classrooms for both school years. While the original focus of the work was on oral discourse, journals were collected in order to give a broader sense of students' expression and understanding of science. I also thought that students' written and pictorial work in their journals would supplement my observations of their

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verbal interactions. In particular, I found the journals to be an invaluable resource for better understanding students who spoke little in small group investigations or whole class conversations.

Student Interviews

I interviewed a subset of students from each classroom usually individually for 30-60 minutes at the end of the first year and during the middle to the end of the second year. Interviews were both video and audio taped. With the help of Mrs. G and Mr. K, we chose students to be interviewed who represented different genders, cultural backgrounds and participation patterns in the class science activities. During the first year I asked students generally about what they did in science class, what ideas they had in the last circle conversation, who participated and how to participate in the circle conversations, and what they wrote about in their science journals. With the broader scope of data collection in the second year, I expanded the interviews to also include students' perceptions of science in and out of school, the role of talk in all of their science interactions and how the oral discourse components of agreeing, disagreeing and reasons were used. Brief descriptions of the students and dates interviewed are listed in the videotape log in Appendix A. Entries of student interviews are shaded in light gray. The protocols for student interviews are found in Appendix B.

Teacher Interviews

I interviewed Mr. K and Mrs. G individually or together at the beginning, middle and end of the first year and at the middle and end of the second year. Interviews were video and audio taped and lasted approximately one hour. During the first year, I asked Mrs. G and Mr. K about the progression of student oral discourse

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over the course of the year, participation patterns of students, potential dissonance between student and conventional science ideas and their teacher collaboration. During the second year, I asked Mr. K and Mrs. G about their strategies for introducing the oral discourse components, their goals for small group investigation and journal writing, and the influence of gender and culture on student learning in science. Brief descriptions of interviews and dates conducted are listed in Appendix A. Entries of teacher interviews are shaded dark gray. The protocols for teacher interviews are found in Appendix C.

Field Notes

I wrote field notes during the collection of all of the data forms. When videotaping classroom interactions, I would periodically check and adjust the frame of the camera. Between adjustments I would write my observations in a small notebook tied with string to the camera tripod. At the start of each class, I wrote general notes about the topic under study and the class format (whole class discussion, small group investigation, journal writing, etc.). Throughout the period I noted patterns of student participation and expression, use of oral discourse components and development of the science content. When students were working in small groups or writing in their journals, I walked around their tables for close observations and occasional conversations with students about their work. During these observations and interactions, I focused my attention on the students' work and talk but would return frequently to a video camera to check the frame and then record my observations of the small group and individual student work in a notebook.

Likewise, I wrote brief notes while interviewing students and teachers about the content of their responses stressing particular or unusual points of interest. As I

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photocopied student journals I jotted occasional notes about entries which especially drew my attention. These notes focused on students' personal expressions and explicit references to conversation that students made in relation to the science content.

Occasionally, I would elaborate my field notes after leaving the classes if I remembered observations that I had not originally noted or thought of potential interpretations I wished to later consider. I delineated original field notes from the later elaboration and placed tentative interpretations in parentheses separate from my direct observations.

Data Analysis

Data analysis began tentatively during data collection with ongoing refinement of the analysis foci. Certain recurring aspects of the classroom interactions repeatedly gained my attention over the course of data collection. In attempting to make sense of my observations, I was influenced by various theoretical writings that I was reading as part of concurrent graduate course work. I found certain theoretical distinctions particularly helpful in making sense of the vast array of data I was collecting. The interaction of prominent features in the classroom data along with consonant theoretical constructs shaped the framework of the analyses.

I first wanted to provide a description and explanation of the norms, values and beliefs of these classrooms. I drew on the basic premise of identifying norms, values and beliefs in ethnography (Van Maanen, 1988) and the rich notions of community developed by education researchers (Magnusson & Templin, 1995; Rogoff, 1994; Roth, 1992; Swales, 1990). These two bodies of literature coalesced with a set of observations of two new students entering the classrooms. The entry of these new students disrupted the communities to some degree as they encountered the class

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norms, beliefs and values. Many of the norms, beliefs and values had been previously hidden in the routine workings of the classroom communities. The entrance of the new students, however, caused some of the norms, beliefs and values to be made visible. The new students did not always know and so did not attend to the expected classroom procedures. Both the current students and teachers helped the new students to gradually transform to become fully participating members of the communities.

I decided the most appropriate research strategy was a case study analysis (Stake, 1994; Yin, 1994) of the new students' entry. I reviewed my field notes for relevant excerpts concerning the new students' entry and transcribed associated videotapes. For the transcriptions I adapted common conventions described by Dressler and Kreuz (2000). The transcription conventions are listed in Appendix D. In order to protect their identities, all student names used throughout the transcripts and analyses are pseudonyms. Through the detailed descriptions of the new students' interactions in the classes I identified some of the general norms and teacher strategies in the class communities. Interview data with one of the students and Mr. K and Mrs. G confirmed and elaborated the observational findings. The complete analysis including specific methods and a full description of the setting is reported in Chapter 4, Introduction to the Classrooms: New Member Entry into Elementary Science Discourse Communities.

The remaining analyses were developed in an effort to more specifically and fully characterize the innovative features of these communities, which allowed students access to science in both alternative and traditional ways. By being open to multiple ways of engagement, Mrs. G and Mr. K encouraged and fostered rich, meaningful interactions with science for the students. In attempting to capture those multiple modes of

engagement, I was assisted by a conceptual framework developed by Kathleen Weiler (1997). In her work studying the history of women teachers, Weiler found three constructs to be of prime significance: knowledge, language and subjectivities. For this study these constructs well captured some of the innovative means used by Mr. K and Mrs. G for engaging students with science.

I first considered knowledge as this construct has been well developed in education research and practice. I examined how knowledge was constructed in representative circle conversations in these classrooms. A relevant debate in the education community is whether convergence or divergence of knowledge should be a goal for students (AAAS, 1993; Barnes, Britton & Torbe, 1990; Denyer, 1993; Heath & McLaughlin, 1993; National Research Council, 1996; Warren, Conant, Ogonowski & Puttick, 1998). I studied how Mr. K and Mrs. G structured the topic of conversations so as to allow both goals of convergence and divergence for productive engagement and construction of science knowledge by students. To analyze knowledge convergence and divergence, I reviewed my field notes and transcribed six representative circle conversations. Using discourse analysis, I mapped each student's knowledge contribution thematically on a timeline. I determined and characterized convergence by like knowledge contributions and divergence by differing knowledge contributions around both the teacher provided topic claim and student generated reasons. Images in this dissertation (including the knowledge maps for this analysis and the conceptual integration figures in chapter 8) are presented in color.

The influence of gender on knowledge construction analyses was informed by my readings of gender and language research by Deborah Tannen (1994) and Carole Edelsky (1993). To determine clustering of like contributions by gender, I again mapped each

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student's knowledge contribution thematically on a timeline. I coded each contribution according to gender and then looked for patterns of clustering of like contributions by the same gender. Gender patterns were confirmed by student interview data.

Furthermore, I became intrigued by the variety of knowledge sources students shared in developing reasons for their knowledge claims. These observations were informed by feminist science authors (Harding, 1986; Haraway, 1996; Hubbard, 1989; Keller, 1985) who have identified and value alternative, little recognized sources of knowledge in the discipline of science. To analyze students' knowledge sources, I coded each student's contribution from the previously analyzed circle conversations according to emergent themes. I then tallied the number of knowledge sources in each theme and looked for patterns of expression by gender, topic and time. I chose to look for patterns in gender, topic and time as these categories were distinctive, included sufficient data and were of a general nature so that I could then consider them in the subsequent language and subjectivities analyses for broader patterns. Other categories such as cultural background and class were of interest, but their complexity or insufficient data prevented complete analyses. The knowledge analyses with specific description of methods are reported in Chapter 5, Knowledge: Convergence/Divergence, Gendered Construction and Knowledge Sources in Circle Conversations.

As with the knowledge analyses I became interested in the varied language forms students used to communicate their ideas about science. Theoretically, I was influenced by Bruner's work (1986) with narrative and paradigmatic modes of thought and observed that students used both modes in their science talk. I decided to look for particular narrative and paradigmatic patterns of expression in the circle conversations. I first developed a list of narrative and paradigmatic features from emergent features in

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the children's conversations and also identified features of narrative and paradigmatic thought in the relevant literature (Bruner, 1986; Dyson & Genishi, 1994; Toulmin, 1958). I then used discourse analysis to identify the narrative and paradigmatic features in the six representative circle conversations used in the knowledge analyses. I determined qualitative narrative and paradigmatic patterns in the students' conversations and then looked for quantitative patterns in the frequency of features by time, topic and gender. The analysis with specific description of methods is reported in Chapter 6, Language: Narrative and Paradigmatic Modes of Talk.

Finally, for the construct of subjectivities, I turned to another data source, student journal writing. I had been struck when first studying the journals by the amount of student personal expression included. In addition, Mr. K and Mrs. G emphasized the importance of written as well as oral discourse in their science instruction, and I wanted to represent these complementary emphases in the study.

For this analysis I made a preliminary listing of emergent themes by reviewing my field notes and perusing the students' journal entries. I then chose a subset of students representative of the classrooms in terms of gender, cultural background and oral and written discourse levels for a detailed analysis. For the subset I wrote an overall description of each journal entry and then listed subjectivities (personal and social observations and characteristics) themes along with knowledge and language themes with evidence supporting each theme. I reviewed excerpts of student interview data in which students discussed their journals and added relevant evidence to the theme analysis. I qualitatively described each subjectivities theme and considered how subjectivities themes were integrated with knowledge and language themes. In addition, I determined the frequencies of the specific subjectivities themes in journals

and looked for trends in the presence of subjectivities themes by gender, topic and time. The description of this analysis along with specific methods is reported in Chapter 7, Subjectivities: Students' Personal Expressions in Science Journals.

Summary

This chapter described the research methodology used in this study. Basically, I followed an interpretive approach with multiple, connected methods to study the norms, knowledge, language and subjectivities features of two elementary science discourse communities. Methods included ethnographic data collection and analyses utilizing case studies, discourse analyses, feminist perspectives and descriptive statistics. I observed and videotaped the science classrooms, conducted student and teacher interviews and copied student journals over a two-year period. Initially, I was interested in the use of oral discourse components by students in science circle conversations but then expanded my focus to look at additional features of the circle conversations, written discourse and student participation. The first analysis was a set of two case studies that highlighted norms and other characteristics of the science discourse communities made visible by the entry of two new students. In the second analysis I used discourse analysis methods to consider knowledge construction along convergent, divergent and gender lines and knowledge sources in children's science conversations. I again used discourse analysis methods in the third analysis to look at the nature of narrative and paradigmatic features in the children's science conversations. In the fourth analysis I drew on feminist perspectives to examine students' personal expression of subjectivities in their science journals and to determine how subjectivities were integrated with knowledge and language in students' drawing and writing. The four analyses are described in detail in the following chapters.

Chapter 4

INTRODUCTION TO THE CLASSROOMS: NEW MEMBER ENTRY INTO ELEMENTARY SCIENCE DISCOURSE COMMUNITIES

Introduction

I would like to introduce the reader to the classrooms studied by describing how two new students, Uchenna and Juwan, entered these novel discourse communities which were very different from traditional, teacher-centered classrooms. In doing this analysis, I wished to better understand and characterize the norms of an elementary student owned science discourse community. By examining the means through which all members adjusted to the entry of new students, implicit norms and values of the community were made explicit. I studied this discourse form to better understand how students gain access to scientific conversations and how to facilitate more students' entry into a scientific discourse community.

In order to get a better understanding of the workings and complexities of this innovative, discourse community, I developed the following objectives for this study.

1. Description of the patterns of interactions that developed in the science conversations
2. Identification of the norms that developed in the discussions
3. Analysis of the role of the discourse components in giving students access to the conversations

General Introduction to the School, Teachers and Students

Before engaging in the specific study of the norms of these discourse

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communities, I will generally describe the setting in which I worked. I chose to study two first-second and second grade classes in Spring Valley Professional Development School. Spring Valley is a K-5 elementary school serving approximately 225 students and is part of a university housing complex. Spring Valley has partnered with the associated university Teacher Education department over many years for the purposes of researching, improving and disseminating strategies for meaningful teaching and learning. The school was chosen, in particular, for this study because of its work over several years in science and literacy integration with emphasis on student oral discourse. As part of this work, teachers and university staff developed a list of oral discourse components (Table 4.1), moves that help facilitate rich and respectful discussions of scientific content. The first-second and second grade classes were further chosen because the teachers, Mrs. G and Mr. K, used a multitude of discourse forms in science instruction including a unique whole class circular conversational format in which students used the oral discourse components of *agreeing*, *disagreeing*, making *claims*, and giving *reasons* to examine a science topic.

Both classes were chosen for study because Mr. K and Mrs. G worked collaboratively teaching and planning their science lessons. Each classroom had between 24-26 students. Many of the students were international, some with beginning English usage. The first-second and second grade classes were made up of 42% girls and 58% boys. Cultural composition in these classes was 59% Asian, 16% African, 12% European American, 6% African American, 4% Latin American, and 1% each of European, Middle Eastern and Native American populations. While there were some differences in socioeconomic status among the students, many of the international students came from privileged backgrounds in terms of educational opportunity within their home countries.

The first-second and second grade students in Mrs. G's and Mr. K's classrooms conducted science investigations and wrote in their science journals during three one-hour periods per week. On a weekly and sometimes monthly basis, they discussed science statements or questions in a whole class circle conversation format. Topics for investigation, writing and conversation included soil, plants, habitats, water, air, physical properties of matter, weather, magnets, and the solar system. The duration of each topic was from two to four weeks. The science sessions were co-taught by both first-second and second grade teachers with assistance at times by one or two interns.

Science investigations typically began with an introduction by the teacher which included some student conversation in a whole class format. Students then spent the majority of the period conducting a pertinent science investigation in assigned or self-selected small groups of four to six members. Students were encouraged to help one another and talk about their group projects. . Mr. K and Mrs. G spent significant time with each group answering and asking questions, prompting group conversation and encouraging student collaboration.

Students typically reported results or wrote about something important from the science investigations in their journals. Mrs. G and Mr. K often gave general instructions to students to write or draw about the investigations studied, but students had a lot of freedom to express themselves in their own ways. Journal writing occurred approximately weekly directly following an investigation or the next day. Students each possessed a science journal that they usually wrote in individually. However, talking with other students during journal writing was encouraged as was orally sharing journal entries with other students.

Science circle conversations occurred weekly and sometimes monthly for 15-30 minutes. Students sat in a circle on a floor of a classroom where furniture had been moved to provide an open space for the conversations. The students had primary responsibility for the circle conversations with occasional but significant facilitation by the teachers. The conversations were similar in some ways to those developed by Gallas (1995), but they also had distinct differences. Both involved whole class conversations in a circular seating arrangement. However, the conversations in this school were based on the use of the developed oral discourse components of *agreeing*, *disagreeing*, making *claims* and giving *reasons*. Mrs. G and Mr. K began the talks by presenting the students with a statement or question about a science topic they were beginning or currently studying for which teachers had previously noted many differences of opinions among students. The teacher would call on the first student to agree or disagree with the statement and encourage the student to give a reason for her/his claim. That speaker would then have responsibility for calling on the next student. In general, the students had primary responsibility for selecting the style and content of their contributions and guiding the conversations with Mr. K and Mrs. G intervening occasionally to introduce a new strategy, remind students when they had broken norms or help students who had difficulty choosing the next speaker.

Most of the claims given by students were valid for the teachers and students. Occasionally, teachers would discount an opinion that was based on fiction such as ones relating to a science fiction movie. All students had the right to express or not express their opinions voluntarily. In rare instances, the teacher would ask a student who had been quiet in a session to give an opinion. Students were not obligated to speak on these occasions. Speaking students had a duty to state their agreement or disagreement with the

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statement or another speaker and give their reasons one person at a time. Students usually also had the duty to call on the next student to speak.

The focus of the following analyses is on the students' circle conversations. These conversations were a unique instructional strategy that gave students ownership of the talk and provided students with many opportunities to express themselves fairly freely. I chose to study the science circle conversations principally because they were owned by students, contexts that have not been fully explored in educational research. Overall, these innovative discourse communities allowed students to experience more open and flexible forms of communication and learning than typically occur in traditional classrooms with teacher-centered discourse.

Theoretical Perspectives

Discourse is an area of sociocultural research that has been significant in this work. Many authors studying discourse use Gee's broad definition of an *identity kit*, while others focus specifically on language. Michaels and O'Connor (1990) discuss the gaining of discourses beyond the discourse of the home as acquiring literacy. In order to control a new discourse, people must learn "particular ways of thinking, acting and valuing" (p. 11).

Various researchers study the influence of culture in acquiring discourses (e.g., Goodwin, 1990; Gumperz & Hernandez-Chavez, 1972; Hayden, Rancic & Thompson, 2000; Moll & Dworin, 1996). Michaels (1990) documented the differences in discourse patterns of African American students and European American students. She found that African American students tend to speak in "topic associating" styles which are characterized by "a series of subanecdotes, without any overt statement of the topic" in which the "overall point had to be inferred." European American students, on the other

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hand, tend to speak in “topic centered” styles where the discourse is tightly structured with a single focus or a series of closely related topics. In classrooms, European American teachers are typically capable of supporting the discourse styles of European American students better than African American students.

Philips (1972) studied cultural factors affecting American Indian student participant structures. She examined the reluctance of American Indian children to speak in school and outlined how the norms governing the Indian children’s discourse came from their home communities. These differences in home and school discourses prevented the formation of a common school speech community. Like Philips, Au (1980) studied the role of culture in Hawaiian students’ reading groups. She found that students were more productive if the teachers and students shared a balance of power in speaking and turn taking rights. In storytelling, many Hawaiian students used a discourse pattern at home of co-narration with overlapping audience responses. In the classroom teachers and students negotiated a *balance of rights* whereby teachers determined the topic of discussion, and students decided the speaker roles and speaking times in order to maintain a cognitive and instructional focus for their lessons.

Heath (1983) described the translation process of working-class African-American students as they “moved between the personalized, contextualized orally-expressed knowledge of home to the depersonalized, decontextualized, primarily written knowledge of the classroom” (p. 321). Gee (1991) argues that students from non-mainstream homes (minority and lower socioeconomic status) often do not have sufficient opportunity to acquire secondary discourses such as those operating in schools. Delpit (1988) explains that there is a “culture of power...based on the culture of the upper and middle classes” in the classroom which is not equally accessible to all students. She

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and other researchers (Kelly & Chen, 1999; Tsai & Garcia, 2000; Willet, Solsken & Wilson-Keenan, 1999) explain that students need to be made aware of the rules in order to acquire power for themselves.

Science educators are also addressing discourse specifically in the discipline of science. Lemke (1990) states that “teachers belong to a community of people who already speak the language of science,” but students do not. Rosebery, Warren and Conant (1990) studied native speakers of Haitian Creole who learn science through various investigations using their native language. Michaels and O’Connor (1990) write about creating a “discourse space” that allows students to bring divergent discourses but which is also orchestrated by the teacher so that students make scientific discourse their own through taking on multiple roles and explicitly talking about discourse.

Feminist researchers are also interested in the appropriation of discourse in the classroom. Human beings are constructed as social beings by language, and Cameron (1992) suggests that that construction is different for women and men. She argues that women may be alienated from and marginal to traditional language created and dominated by men. Cameron goes on to cite the “inequality of conversational opportunity” (p. 71) between women and men and attributes this inequality to lack of access to powerful discourse styles (Lakoff, 1975) and/or men’s linguistic privileges due to their socially dominant position.

Children’s speaking styles show distinctive differences according to gender. Maltz and Borker (1982) postulate that some of these differences arise out of girls’ and boys’ play groups. Girls emphasize intimacy and reduce conflict as a result of interactions in small play groups. Boys develop direct, confrontational speaking styles due to large, hierarchically organized play groups.

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Cameron (1992), however, cautions against a monolithic analysis of language based solely on gender. In acknowledging the impact of gender on our identification as social beings, Cannon, Higginbotham and Leung (1991) state that race and class are critical features that shape us and must also be brought explicitly into the research process. In terms of race, Conway and Bourque (1993) substantiate women's inequality due to "access and educational experience" in Asia, Africa and Latin America as well as in the United States (AAUW, 1992).

To examine the context of discourse in classrooms, I also drew on literature about community. Swales (1990) has identified six characteristics that identify a discourse community. Rogoff (1994) discusses the development of a community as a "transformation of participation." Science educators (Magnusson & Templin, 1995; Roth, 1992) have established norms of communities within science classrooms.

Methods

I first identified specific video segments containing the entry and progression of two new students into the circle conversations. Analysis procedures began with detailed observations and then selected transcription of the new students' interactions in the conversations. Attention was paid to the language used by students and nonverbal gestures. I proposed primary assertions about patterns of interactions, group norms and the role of the discourse components in the conversation. These assertions from the conversation videotapes were supported or disconfirmed with other data sources including teacher and student interviews. I report the findings as case studies of the two new students' entry into the discourse community.

New Member Entry into the Science Discourse Communities

During science and literacy data collection in these classrooms, two new students, Uchenna and Juwan, joined the elementary classes. Their arrival provided an opportunity to better study the operations of the discourse communities. As these students attempted to gain access to the groups, norms were broken and/or highlighted. I examined the processes that the new students, the existing students and the teachers went through to facilitate the smooth operation of the oral science discourse communities.

Uchenna's and Juwan's stories provide a detailed introduction to the discourse communities and their norms. I have written about their stories in narrative form below and have given shortened timelines of their entry in Figures 4.1 and 4.2.

Case 1: Uchenna's Story

Uchenna was an African girl who was a new student midway through the school year. Uchenna was initially very reserved, but her nonverbal gestures of leaning forward and looking at each speaker suggested that she was an active listener and engaged on that level in the children's discussions. After about a month's time, Uchenna began raising her hand in the science conversations.

During one conversation students were considering the question, "Did dinosaurs all live on earth at the same time?" When their teacher, Mr. K., introduced the question, Uchenna waved her hand anxiously. She was not called on to speak during this discussion, but she leaned forward and looked at the other speakers. At the end of the session, Mr. K asked if anyone who had not spoken would like to at that time. He emphasized that students did not have to talk. Uchenna did not raise her hand. Mr. K then commented on the group participation highlighting Uchenna's attentive listening.

Mr. K: Thank you very much. I think that we had a lot of people participating today. Um, the only thing that I would ask maybe next time is that even if you're not participating by raising your hand, you still need to be paying attention. And the people who have already raised their hand, just because they talked once doesn't mean they don't have to pay attention. Okay. Sook-Joo spoke, and she paid attention. Uchenna did not say anything, but she was paying attention the whole time.

Raising one's hand was an explicit norm of the community indicating that a student had something she/he wished to share with the group. Ordinarily, the present speaker may call upon a child with his/her hand up. Usually many students raised their hands to speak. Uchenna's initial bid for speaking rights was not recognized by the discussion speakers, and she was not called on to have a turn. When she was given the opportunity to speak by Mr. K at the end of the session, she did not raise her hand. Another student may have stated her initial point, or she might have felt uncomfortable speaking in this special format created by the teacher rather than in her regular peer community.

A few weeks later the students were discussing the statement, "The stars are always shining." Lucas had spoken and was deciding whom to call on next.

Lucas: (Lucas pausing to pick someone. Someone whispers Uchenna's name. Uchenna has her hand up.) Jill.
Jill: I have a question. Are there clouds in outer space? (Uchenna still has her hand raised and is waving it throughout Jill's turn.)
Mr. K: Okay, we'll answer that one later, too...Uchenna.
Uchenna: I agree (other students talking)
Mr. K: Wait a minute, Uchenna. (students quiet). Okay.
Uchenna: I agree that when the sun is shining you can see the stars but the sun is so bright. At night, you can see the stars even better. The stars are shining.
Mr. K: Why can you see them better at night?
Uchenna: Because, at night, the sun is not shining like (rest inaudible).
Mr. K: Okay.

Even though a student had suggested Uchenna's name to Lucas, he chose another student Jill who often spoke in the science conversations. Mr. K saw Uchenna's interest

in responding to the statement and so broke the convention of students choosing speakers in order to give Uchenna access to the conversation.

During her first speaking turn, Uchenna correctly followed the norms she had observed in the group. She first *agreed* or *disagreed* with the topic sentence and then gave a *reason* for her agreement or disagreement. Uchenna was also able to *elaborate* her response when prompted for more information by Mr. K. Uchenna then called on another speaker from the group of students with raised hands. She was able to successfully complete all of the conversational moves used by the other members of the community. However, entrance to the community was her major obstacle. She required the assistance of the teacher to become a verbally participating member. Even after Mr. K gave her a speaking opportunity, the other students initially continued to talk amongst themselves. Again, Mr. K needed to remind them to listen to Uchenna. It appeared that she was invisible to the other students.

After a few more sessions, the intern teacher, Ms. C intervened during the discussion, noting students who had their hands raised to speak and had not had a first turn. Allowing each student who wished to speak a first turn before second turns were granted was a norm that evolved during the year. The teacher was working at this point to make that norm explicit and routine. She mentioned two students' names including Uchenna as possible choices for the present turn.

- Ms. C: Who else has something to say for Gary to pick on? Some people haven't had a turn like Uchenna and Rati. Uchenna and Rati haven't had a chance yet.
- Gary: I pick
- Ms. C: That means you should pick one of those two.
- Gary: Jill.
- Ms. C: Gary, what did I say?
- Student: Pick Uchenna.
- Gary: Okay, um, I pick (some students whisper Rati's name), um, Rati.

Ms. C: Thank you.

Ms. C continued to suggest those students wishing a first turn as each new speaker was being chosen. Uchenna was not chosen as a speaker following these prompts. Eventually, Uchenna became the only suggestion as most students who wished to had had a first turn. Uchenna was still not chosen as speaker. Instead, a second turn was granted to another student. The teacher reprimanded this move, and Uchenna was again chosen by the teacher to speak. Typically, the teacher permitted the students to determine turn taking. However, the teacher would intervene if there were too many girl or boy turns in a row, if a few people were called on continuously or if a student like Uchenna wanted to speak but was not chosen by other speakers.

Perhaps because she was a new student, the others were not in the *habit* of seeing Uchenna as a possible speaker in science conversations. Another interpretation is that the other students intentionally ignored Uchenna. During her first occasion in the group, there was a great deal of physical space between her and other students. The students always sat on a floor in a fairly tight circle. Typically, students of the same gender often sat together in clusters. Uchenna, however, sometimes sat between two groups of boys. She was quiet and well behaved acting in stereotypical ways attributed to girls.

As the year progressed, the other students gradually came to treat Uchenna as a fully participating member. In one of the final sessions, a popular boy Evan explicitly expressed some of the norms the teachers had been working on over the course of the year. When Evan was deciding whom to pick to speak next, he stated the following:

Evan: Uchenna. She hasn't had a turn yet.

Not only had Evan recognized Uchenna as a member of the group, he was also conscious of the fact that she had not yet had a first turn.

When I interviewed Uchenna at the end of the year, she was initially reserved and skeptical of the interview purpose. She asked another student who was leaving the room what the answers should be. I assured her that I was only interested in her ideas. Whatever her ideas were was the correct answer. She soon relaxed, stretched out on the carpeted floor and told me enthusiastically about that day's science statement and why she disagreed with it. I asked her how she learned to participate in the science conversations.

- Lori: You came to the school part way through the year.
Uchenna: Yeah.
Lori: You came in, and on Fridays you came around and talked in a circle, and was that something new for you to do
Uchenna: Yeah.
Lori: when you first started at Spring Valley? How did it feel?
Uchenna: Well, I just copied others when they talked about something, and then I started talking, 'cause I knew what was happening now...
Lori: Was that hard? Was it hard to learn how to do that?
Uchenna: No.
Lori: Was it easy?
Uchenna: Yeah, easy.

At this point Uchenna seemed very comfortable with the structure of the weekly science conversations and seemed to be pleased with her ability to participate. Whether or not that transformation was difficult for Uchenna is hard to assess. However, at the end of the year, she appeared to be confident and enthusiastic about her membership in the science discourse community.

Case 2: Juwan's Story

Juwan was an African American boy who also entered his classroom as a new student midway through the school year. His strategies for gaining entrance were very different from Uchenna's, however. He began by making noises when other students were talking and physically moved around a lot. His teacher, Mrs. G, would help him to

sit properly and quietly when he first entered the science conversations. On his first day, the class was addressing the questions, “When did dinosaurs live? Did they all live on earth at the same time? What do you think?” Juwan’s vocal nature brought attention to him in the conversations. Unlike Uchenna he was called on to speak during his first conversation.

- Darweshi: Juwan, what do you think?
- Juwan: I think that dinosaurs lived THOUSANDS of years ago, and um, and, and, dinosaurs, she (previous speaker) said three periods, but I have a book about dinosaurs, too, and it said that they had ten time periods, and some dinosaurs were meat eaters, and some were plant eaters (pauses and looks around).
- Mrs. G: Can you name any of those time periods, Juwan? Do you remember any of their names? If anybody remembers the names of the times, like I said just long ago, but some people have other ideas who would like to, Juwan, call on somebody. If you don’t know their name, just point to them and say, “What do you think?”
- Juwan: Okay (pauses, looks around). Um, Steven, what do you think?
- Alisha: He didn’t raise his hand.
- Juwan: Okay.
- Mrs. G: Okay, Steven, call on someone else.
- Steven: He-Ping.
- He-Ping: I agree with Darweshi and disagree with Juwan
- Juwan: [
- He-Ping: oop because dinosaurs lived 35 million years ago, and they extinct down, and Darweshi was right because dinosaurs did not live at the same time as humans because they were already monkeys.
- Juwan: Monkeys!
- He-Ping: No, they just, NOOOOOO! (to Juwan who is still talking while others are laughing)
- Mrs. G: (to Juwan) This is, excuse me, I won’t be scolding you because you’re new, but we wait until it’s our turn.

In his first speaking turn Juwan encountered many of the norms of the group. He stated an opinion and gave his reason for it. However, unlike most of the other students, he did not preface his opinion by saying, “I agree,” or “I disagree.” Even though he began by saying, “I think,” he used an authoritative tone emphasizing important words in

his statement like THOUSANDS. He also cited an authoritative reference, a book he had on dinosaurs, to refute a previous speaker's opinion. Unlike Uchenna, he did not respond to the teacher's bid for more information.

At Mrs. G's prompting, Juwan did attempt to choose the next speaker, though. He picked a student Steven whose name he knew but whose hand was not raised. He might have considered Steven a friend. However, Juwan violated the norm of choosing someone whose hand was raised, and another student, Alisha, quickly corrected him. Mrs. G then intervened, and asked Steven to choose another speaker. As He-Ping began sharing his idea, Juwan made a noise when He-Ping disagreed with him. As He-Ping continued, Juwan again broke the norm of waiting to speak until you raise your hand and have been chosen by the previous speaker. He seemed surprised at He-Ping's comment about monkeys and said so. Juwan's violation of the speaking norm or the controversy of He-Ping's statement caused additional murmurs among the other students. Juwan started to say more when He-Ping stopped him by saying, "NOOOOOO!" He-Ping knew that Juwan had violated the norms and was interrupting his turn. He did not seem quite certain how to handle the violation and so eventually became angry and stopped the conversation. Like Alisha he attempted to inform Juwan of the norms of the group. Mrs. G also stepped in at this point and explained to Juwan that he must raise his hand if he wanted to speak.

Juwan initially interrupted other students' speaking turns when he disagreed with them. He would state his opinion as the *truth*. When Juwan violated the routines of speaking only when you are called on and framing your statement as an agreement or disagreement not truth, both the teacher and other students reminded him explicitly of these group norms.

Later during that same conversation, Juwan had another opportunity to practice the scientific discourse.

- Juwan: For one thing, talking about dinosaur movies, for one thing, I read a book that it said, the name of the book was Real Stories about Dinosaurs and People. Cave men looked like monkeys, but mon, but they were not monkeys. No,
- [
- Mrs. G: What does that have to do with the dinosaurs?
- Juwan: Dinosaurs (pause), see, the dinosaurs, the dinosaurs were in there, but it said, the dinosaurs were living. People were living, but they were cave men, no women (whispers from other students).
- Nimah(?): Yeah, there's cave women.
- Mrs. G: This is his opinion. It doesn't mean it's right or wrong. He might be wrong, but that's his opinion. He's allowed to have it.
- [
- Juwan: And, um, and no animals. I mean
NO ANIMALS. Not monkeys, not tigers, not lions. There were no animals.
- Mrs. G: But dinosaurs.
- Juwan: But dinosaurs. Not
- Mrs. G: So you don't call dinosaurs animals.
- Juwan: No. Dinosaurs are reptiles.

In this turn, Juwan still did not adopt the norm of prefacing his idea with *agreeing* or *disagreeing*. He again used an authoritative tone and appealed to a more authoritative reference, a book entitled Real Stories about Dinosaurs and People to refute He-Ping's point about people being monkeys. Mrs. G asked Juwan how his comments related to the issue at hand alluding to the norm that contributions only be made which are relevant to the science topic being discussed. Juwan then attempted to address dinosaurs and show how his idea was relevant to the conversation, but he still included his point about cave people saying that they were alive at the time of dinosaurs.

When Nimah disagreed with Juwan, Mrs. G stated that he was allowed to have his own opinion. With this contribution Juwan also responded to Mrs. G's queries for more

information. He answered her confidently and definitively, giving reasons he thought to be factual.

Juwan gradually learned to raise his hand when he wanted to speak, but, in the beginning, he continued to make noises to get the attention of the speaker. After some experience he stated his agreement or disagreement with the statement or previous speaker. As he stated his reason, however, he would use an authoritative tone that implied *truth*. Later in this conversation, another student used his turn to tell Juwan that one might have many sources for their reasons such as books or personal experience. He tried to tell Juwan that there was not one right answer to the issue they were discussing.

A few weeks later, the students were discussing the statement, "The stars are always shining," as Uchenna's class had done. Juwan was included in the conversation by another boy, Boseda.

- Boseda: Juwan, what do you think?
Juwan: Um, I disagree with Alisha and Audrey because
Mrs. G: I can't remember what they said. Tell us what it is you disagree with.
Juwan: Audrey and Alisha said that the sun gives the, um, the stars light so that at night they would have, mm, so that they would shine.
Mrs. G: Mmhmm, you disagree with that because
Juwan: Because they said that they didn't shine, but at daytime, yes, they always shine. But, but, it's just that the sun has more light, more than them, and it's so, and it's so bright outside, and you just can't see them...
Mrs. G: Call on somebody. Very nice. Call on a girl. We haven't had a girl in a while.
Juwan: Okay. I'm going to call on a girl who hasn't had a turn yet. Boys, you should put your turn, your hands down.
Alisha: You're not the boss.
Juwan: Well, I ain't picking on boys.
Mrs. G: I know. Instead of saying, "Boys you should," say, "Boys, you might want to."
Juwan: Okay.
Mrs. G: Try that.
Juwan: Boys, you might want to put your hands down.
Mrs. G: Yeah, that sounds friendlier.
Juwan: Audrey.
Audrey: I didn't raise my hand.

In this turn Juwan used the convention of agreeing or disagreeing and was able to use a more sophisticated move of *paraphrasing* what the previous students had said when he was prompted by Mrs. G. He did not reference a book in this turn but still used an authoritative tone saying, "...yes, they always shine."

As Juwan struggled with notions of scientific *truth* in the conversations, he also struggled with appropriate social etiquette. Once he understood that he must raise his hand to be called on, he then had some difficulty managing his responsibility to pick the next speaker after he had spoken. In this turn he used an authoritative tone with the students saying that he would not pick boys. Again, a student Alisha stepped in and told him that his tone was not appropriate. In a later session, Juwan still used social authority inappropriately in exercising his right to choose the next speaker. He told the students that he would only pick on someone who was nice to him. Mrs. G stepped in and asked him not to use his responsibility as a punishment towards the other students. She reminded him that it was important to speak respectfully to the other students.

Juwan became more and more adept at the conversational moves with time, but he continued to be a vocal and often outspoken member of the group. Unlike Uchenna, Juwan acted in very verbal and explicit ways to become a member of the community. His loud and forthright mannerisms were stereotypical of boys' behavior. Both students, however, acted less in stereotype as they became more fully participating members of their classes. Uchenna became more vocal and participated as a speaker and listener with time. Juwan became more attentive to other speakers' rights and respectful of their opinions.

Characteristics of the Discourse Communities

Several features of the discourse communities arose from Uchenna's and Juwan's stories. Below I attempt to characterize some of these features and norms thematically.

Student Ownership of the Conversation

By studying the novel format and new student entry into these discourse communities, I found that student ownership was a key factor distinguishing these conversations from more traditional discourse forms in school. In an interview in the middle of the year Mr. K and Mrs. G described their conceptions of the learning community.

- Lori: What are the specific aspects that make it a learning community?
Mr. K: They're starting to see it as their own. They have a little ownership of that, and that it's their learning. And they control it somewhat, and by calling on each other, and having a civil conversation about a topic and hearing what each other has to say.
- Mrs. G: And again that whole thing of having everybody facing each other has some real value...
Lori: What [else is] happening to make this a learning community?
Mrs. G: And being asked to listen. Whether or not, that's really occurring is hard. It's so covert. Modeling is part of the model, and reinforcing their behaviors by bringing attention to specifically what they did and why.

Mr. K articulated one of the key features of the conversation, student ownership. The student ownership along with the teacher's careful attention to appropriate intervention created a more equitable balance of power between the teachers and students. Mrs. G's emphasis on the physical arrangement of the students in a circle looking at and listening to each other allowed for respectful and serious discussions among the students. Mrs. G also focused on making the group norms explicit thus permitting new students like Juwan and Uchenna to readily see how these unique groups operated and to quickly join them in ways acceptable to the other

students.

New Student Entry

Overall, all members of the community required a “transformation of participation” (Rogoff, 1994). Uchenna initially appeared invisible to the other students in her class. She was very quiet, listening attentively but not verbally participating in the conversation. When she did attempt to speak, the other students did not give her access to the conversation. Her teachers, Mr. K and Ms. C, initially had to include Uchenna as a speaker. Eventually, the other students came to see Uchenna as a full member of their community. Their *transformation* took time and required the teacher’s assistance.

In Juwan’s case, the students actively helped in his *transformation* along with the teacher. Perhaps because he was so vocal in asserting his opinion, the students felt it necessary to help him understand what the norms of the group were. They may also have felt his entrance as an unwelcome intrusion to the smooth operation of their community. They may have thought it was their responsibility to maintain the community in ways in which they were comfortable and safe. Also, they may not have wanted the changes Juwan was initially making in the group. As with Uchenna, the teacher stepped in at times to facilitate. Rather than addressing the other students, however, Mrs. G usually reminded Juwan of a group norm that he had broken. Juwan, too, was an active participant in the transformation process as shown by his adoption of group norms and acceptance into the community as a fully participating member.

The new students initially acted in gender stereotypic ways (Jones et al., 2000; Wortham, 1995) which affected their entry into the conversations. Uchenna’s very quiet and unobtrusive manner and Juwan’s loud and boisterous ways fit traditional stereotypes attributed to girls and boys. Uchenna’s shy behavior made her unnoticed by her peers.

When she attempted to participate orally, other students did not seem to see her raised hand. She required the support of her teachers to enter the students' conversations. Juwan's very vocal behavior caused him to be noticed and included in the science conversations from the very beginning of his entry. The students acted less in gender stereotype as they became more fully participating members of the discourse community. The other students recognized Uchenna when she raised her hand, and Juwan attended to the norms of raising one's hand to speak, speaking only when called on and listening respectively to others.

Norms of Participation

The other students' responses to the new students indicated that they had internalized both explicit and implicit "rules" or norms of participation including the following:

1. The speaker has the role of selecting the next speaker.
2. Raise your hand when you want to speak and only speak if you have been called on.
3. Listen and look at the speaker.
4. Student contributions should be statements of *agreement* or *disagreement* with the statement being discussed or another student's response. Students may add *reasons* for their opinions.
5. Contributions are given in the belief that they are relevant to the topic being discussed.
6. Students should speak and listen in respectful ways.

The teachers reinforced the norms of participation by commenting when a norm had been well adhered to or violated.

Uchenna described the basic procedures of the science conversations in an interview at the end of the year.

- Uchenna: The one like, first you got to read what it says on the chalkboard (statement to be discussed in the circle conversation). When you say it, you got to say something, and then call on someone. Like Mr. K started that, and then he does that...
- Lori: Is it easy or hard to talk on Fridays?
- Uchenna: It's easy.
- Lori: Why is it easy?
- Uchenna: 'Cause all you got to do is talk what you know about science.

At this point she was thoroughly knowledgeable and comfortable with this discourse pattern that was so very different from typical instruction-response-evaluation talk between students and teachers in schools.

Access to the Conversation

The following norms were observed regarding students gaining access to the conversation.

1. Every student who would like to make a contribution has an opportunity to participate.
2. Speakers give every student a first turn before second turns are granted.
3. Students take responsibility for including all students in the discussion.

In some ways these norms were in conflict with the previous norm stating that each student had the right to pick the next speaker. The teachers used several different strategies in attempting to moderate this potential tension and give more students access to the conversations. Examples of teacher strategies include the following:

1. Teachers would step in to call on a student who had been ignored on several occasions, would point out students who had not been called on, or would instruct students to call on those who had not yet had a turn.

2. Teachers tried to establish a new rule that everyone who wished to speak should have a turn before other speakers had a second turn.

Uchenna's story illustrated the above norms, and she recited the appropriate conventions for following these norms in her interview.

Lori: After you have had a turn, how do you decide who to pick on when there are lots of children raising their hands?

Uchenna: No, you just pick who didn't have a turn yet, and then who had a second turn, get another turn, and the rest get another second turn. If someone still got none turn, and he, and she or he's still raising their hand, that's when you call on her.

A student in Mrs. G's class Ellen also described the importance of calling on someone who did not have a first turn.

Lori: How do students get picked to talk?

Ellen: By raising their hands.

Lori: Now, when you talked, and you talked today, and the people are raising their hand, how do you decide who to pick on, who to pick to talk next?

Ellen: Um, you just pick, sometimes, you pick the one who hasn't got a turn, or sometime you pick a second person who needs another turn.

Another student, Preston, in Mr. K's class, however, discussed different criteria for choosing speakers than those explicitly expressed by the teachers attempting to give many students access to the conversation.

Lori: How do students get picked to talk?

Preston: They raise their hand.

Lori: Okay. When someone has picked you, and you have agreed or disagreed with the statement and told why, how do you decide who to pick next?

Preston: By looking at who's raising their hands.

Lori: All right. And then once you look at everyone who's raising your hand, do you pick the first one that you see, or do you have to make another decision once you see the hands raised?

Preston: You decide who you pick.

Lori: And do you have an idea about how you decide?

Preston: I decide the people I like.

Lori: Are they the friends that you have?

Preston: No, I think if they are a little smart.

Lori: Okay, and how do you know who's a little smart?

Preston: Because when I first started a science statement, I heard them say, and

they say why very good.

Many students described the explicit norms of choosing speakers which allowed more students into the conversation. However, some others besides Preston emphasized their right to choose the next speaker based on their own criteria such as choosing students with “good” reasons, friends or students of the same gender.

Authority within the Individual

An important characteristic of these student owned conversations is that authority resided within individual students (van Zee, 2000) rather than in the teacher or external sources (Smith & Anderson, 1999). Norms related to this feature of the community include the following:

1. There is a considerable amount of authority about “truth” located within the individual.
2. Everyone has a right to her or his own opinion and to change their opinion if they choose to.
3. Opinions supported by reasons are encouraged but not required.

Uchenna described her notions of authority in the conversations by defining the terms *agree* and *disagree*.

Lori: Now I know one thing when I’ve been watching that the children do is they say, “I agree with the statement, or I disagree.”

Uchenna: [Yeah, I disagree.

Lori: Is that something you copied when you first came, to say agree or disagree?

Uchenna: Yeah. I was thinking, “What’s agree and disagree?” Now I know. Agree is “Yes, I know.” Disagree means “No, that’s not right.”

Lori: Oh. So, how did you learn what agree and disagree meant?

Uchenna: ‘Cause like when we did our test in social studies, Miss W told us that agree is “Yes, I know,” and disagree is “No, I don’t.”

Lori: Okay, and then when you were talking in science, you heard agree and disagree again, and then, you knew it was the same for here?

Uchenna: Yeah...

Lori: Does it help to say agree or disagree rather than just saying your idea?

Uchenna: Yeah.

Lori: How does that help?

Uchenna: Because sometimes you might not know stuff, and you might think it. You might not know stuff, and then you think, and then, now you know what this is, but you really didn't know. Now, when, when you get it correct, now, you said, "How did I get it correct?" Well, you didn't know.

Lori: Uh huh. So if you say agree or disagree, is this a way of saying, "Well, I'm not really sure, but this is what I think."

Uchenna: Yeah, yeah.

Lori: Rather than saying, "This is correct," or "This is wrong."

Uchenna: Yeah, yeah.

In conducting and rereading the interview, I am not certain that Uchenna's ideas about the meaning of *agree* and *disagree* were the same as what I suggested. However, the interview does demonstrate Uchenna's evolving thinking about notions of authority. She seemed to start out with traditional views of right and wrong. *Agree* meant that "you knew" and *disagree* meant that "it's not right". However, her next statement indicated that she was thinking about a more complex, less definitive conception of authority that included not knowing. Juwan showed this same struggle in his responses in the discussions. He began with definite assertions about right and wrong but then later used the *agree* and *disagree* format locating his knowledge within himself rather than an external authority. (Juwan left school before the end of the year and was not available for an interview.)

Teachers' Roles as Facilitators and Observers

As the teachers attempted to put social control of the conversations in the hands of the students, they commented on how their own roles had changed to facilitators and careful observers of the conversations. Mr. K discussed how the students' ownership of the conversations was very important and how he tried to facilitate that process.

Lori: Will you talk about this aspect of students calling on each other?

Mr. K: ...It's just giving the children more control over the conversation. It's their conversation. Why should we stick in and call on people? So, you know, and you still get kids who have to decide, although that's not happening so much, anymore. They're calling on each other more without having the big conflict of "Who do I call on?"

Lori: What do you see as your role in the conversations?

Mr. K: My role is to manage basically, and I will step in and ask a question if I think it's necessary, and maybe it's to lead them to a different question or a different statement, or to get some clarification and to keep some of them tuned in, but I try to stay out as much as possible. But, you know, and to make them aware of some other things they could ask, or something that I thought. Oh, I know what I forgot, summarize what we've heard at the end, model that, so at the end of the year I can say, "Preston, what did you hear the most?" or something like that.

Mrs. G also discussed the pedagogical benefits of having a different role in the classroom where the teacher can be a more attentive observer of the students' ideas.

Mrs. G: ...I'm so actively participating with them in the classroom, where in this setting, I can sit back and a little more watch. I have a better idea of their participation level as an observer...It's been nice that the kids are comfortable to let me sit out and to let me come back in to readjust something.

Summary

This analysis identified some of the characteristics and norms of the discourse communities in Mr. K's and Mrs. G's elementary science classrooms. The analysis was conducted through the examination of the entry of two new students, Uchenna and Juwan, along with the other students' and teachers' responses to the new students' entry within the discourse communities. As Juwan and Uchenna attempted to gain access to the science circle conversations, norms were broken and/or highlighted. The entire communities underwent a *transformation of participation* in adjusting to the entry of the new students. Both Uchenna and Juwan initially acted in ways stereotypical of their genders. Uchenna was quiet and reserved and often ignored by the other students. She, therefore, required a great deal of support from her teacher. See Figure 4.1 for a summary

of critical events in her entry and acceptance into the discourse community. Juwan was loud and outspoken and was assisted by both the students and teacher in recognizing the norms of the group. See Figure 4.2 for a summary of the pivotal events in his entry and acceptance into the discourse community.

Additionally, through the construction of the community as student operated and the use of the discourse components, *agreeing* and *disagreeing*, students developed a location of authority within individuals. The new students required time and practice to adjust from traditional, external conceptions of authority to internal, individualistic understandings.

The characteristics and norms of these discourse communities are summarized in Table 4.2. In the table I attempted to show the negotiation and progression of student ownership by identifying norms for which the students were primarily responsible (in bold) and norms for which the students and teachers shared responsibility (in italics). The table shows the evolving nature of the discourse communities. Students took on primary responsibility for upholding norms of participation with some assistance by the teachers for norms of topic relevance and respect. Students also quickly internalized and maintained responsibility for most of the norms about authority within the individual. However, much teacher support was required in establishing and sustaining norms regarding equal access to the conversation. These innovative discourse communities grew through a dynamic balance between necessary teacher support at critical junctures along with gradually increasing student appropriation and responsibility for science conversations they considered to be their own.

Discussion

This study provides a beginning understanding of the workings of an innovative, discourse community and alludes to many of the issues analyzed further in the next three chapters. Throughout all of the analysis chapters, there are recurring themes of both *expansion* and *constraints* within the discourse communities. In exploring alternative ways of teaching and learning science, Mrs. G and Mr. K, along with their students, open novel and exciting avenues as well as experience distinct and sometimes unexpected obstacles to understanding science.

This community provided opportunities for *expansion of the discourse* (Weiler, 1988) that are often missed in traditional lecture or initiation-response-evaluation (Cazden, 1988; Lemke, 1990) forms of discourse. By studying the new students' entry into the community, I could see that involvement required a collaborative, *transformative* effort by both teachers and students. In addition, these discourse communities allowed students to have more ownership and autonomy of their science learning. The structure of the science conversations encouraged students to have *individual authority* while at the same time be respectful and open to others' opinions. Student ownership of the conversations created different roles for the teachers as well. They became more attentive observers and facilitators of the conversations.

In this analysis, there were also some *constraints* to the discourse. I saw how the norm of choosing the next speaker sometimes conflicted with the norm of including many students in the conversation. Over time many students adopted the norm introduced by the teachers to give every student a first turn before second turns were granted. However, some students had other criteria like friendship, gender or persons with "good" reasons guiding their choices of next speakers.

As evidenced in this first analysis, these students with the support and guidance of their teachers, Mr. K and Mrs. G, explored new and complex territory in both classroom learning and teaching of science. These new locations involved different conceptions of what is included in science knowledge, different ways of communicating about science and different ways of expressing one's thoughts and feelings about science. These areas are the subjects of analysis for the next chapters which focus on combining alternative and traditional conceptions of knowledge, language and subjectivities within the elementary classrooms.

Realizing that tensions exist in all discourse communities, I am highly encouraged by the level of student ownership and quality of scientific discussion present in these student conversations at such a young age. How the teachers and students managed to accomplish this degree of serious science talk and student autonomy cannot be fully explored in this study and requires further analysis. I am very interested in further understanding the process of developing and shaping norms within these innovative, student owned science discourse communities.

Table 4.1 - Oral Discourse Components for Spring Valley Elementary Science Conversations

Developing and defending arguments Making and supporting a statement	
Making a claim: A statement which proposes a certain fact (some fact is in dispute), value (something is right or wrong), or policy (something needs to be done/changed) Supporting claims with reasoning: Providing support for a claim in an effort to persuade others (e.g., with statistics, examples, visuals, analogies) Suggesting/inviting an argument: Suggesting an issue for discussion	
Listening: Keeping track of the flow of arguments	
Disagreeing: Disagreeing with another student's statement Agreeing: Supporting another student's statement Elaborating on an argument already started: Providing more information to another student of the group in order to build a stronger argument	
Encouraging: Being an advocate, helping all to participate	
Providing feedback: Responding to someone else's statement	
Paraphrasing:	Making a statement, typically beginning with a tag like, "I think she is saying," in which the purpose is to put into other words what another has said in order to check for understanding
Questioning:	Asking for more information, another example or for someone to clarify a point
Summarizing:	Providing a condensation of another's statement
Clarifying:	Making a statement which seeks to make another student's point clearer to the rest of the group

Table 4.2 - Characteristics and Norms of Student Owned Science Discourse Communities

New Student Entry Characteristics

1. Entry into the conversation of the new students required a "transformation of participation" (Rogoff, 1994) by the other students and teacher as well as the new students themselves.
2. The new students initially acted in gender stereotypic ways (Jones, et al., 2000; Wortham, 1995) which affected their entry into the conversations. The students acted less in gender stereotype as they became part of the discourse community.
3. The new students initially had a more authoritarian view of "truth".
4. Change in understanding the nature of authority in the conversation represented a difficulty or challenge as the new students attempted to participate in the conversation.

Norms of Participation

1. **The speaker has the role of selecting the next speaker.***
2. **Raise your hand when you want to speak and only speak if you have been called on.**
3. **Listen and look at the speaker.**
4. **Student contributions should be statements of agreement or disagreement with the statement being discussed or another student's response. Students may add reasons for their opinions.**
5. *Contributions are given in the belief that they are relevant to the topic being discussed.**
6. *Students should speak and listen in respectful ways.*

Norms Regarding Access to the Conversation

1. *Every student who would like to make a contribution has an opportunity to participate.*
2. *Speakers give every student a first turn before second turns are granted.*
3. *Students take responsibility for including all students in the discussion.*

Norms about Authority within the Individual

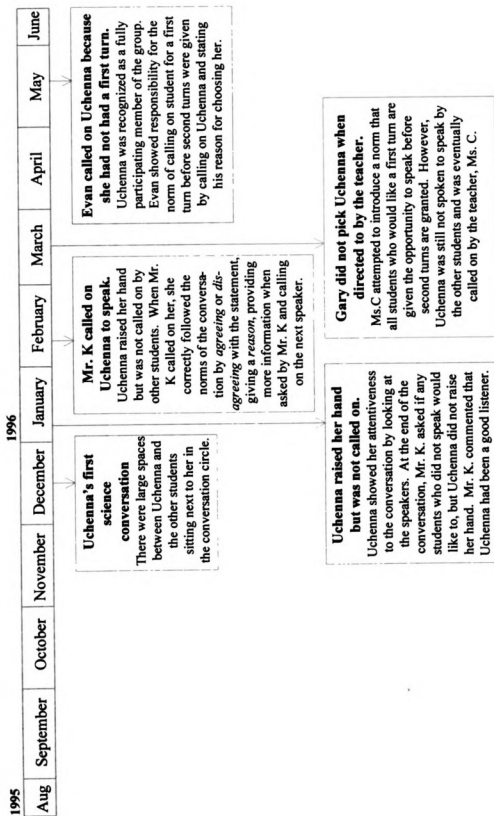
1. **There is a considerable amount of authority about "truth" located within the individual.**
2. **Everyone has a right to her or his own opinion and to change their opinion if they choose to.**
3. *Opinions supported by reasons are encouraged but not required.*

Some Teacher Strategies to Facilitate Conversations

1. The teacher often commented when a norm had been well adhered to or violated.
2. Teachers would step in to call on a student who had been ignored on several occasions, would point out students who had not been called on, or would instruct students to call on those who had not yet had a turn.
3. Teachers tried to establish a new rule that everyone who wished to speak should have a turn before other speakers had a second turn.

***Bold norms were the primary responsibility of students.**

+ *Italicized norms were the joint responsibility of students and teachers.*



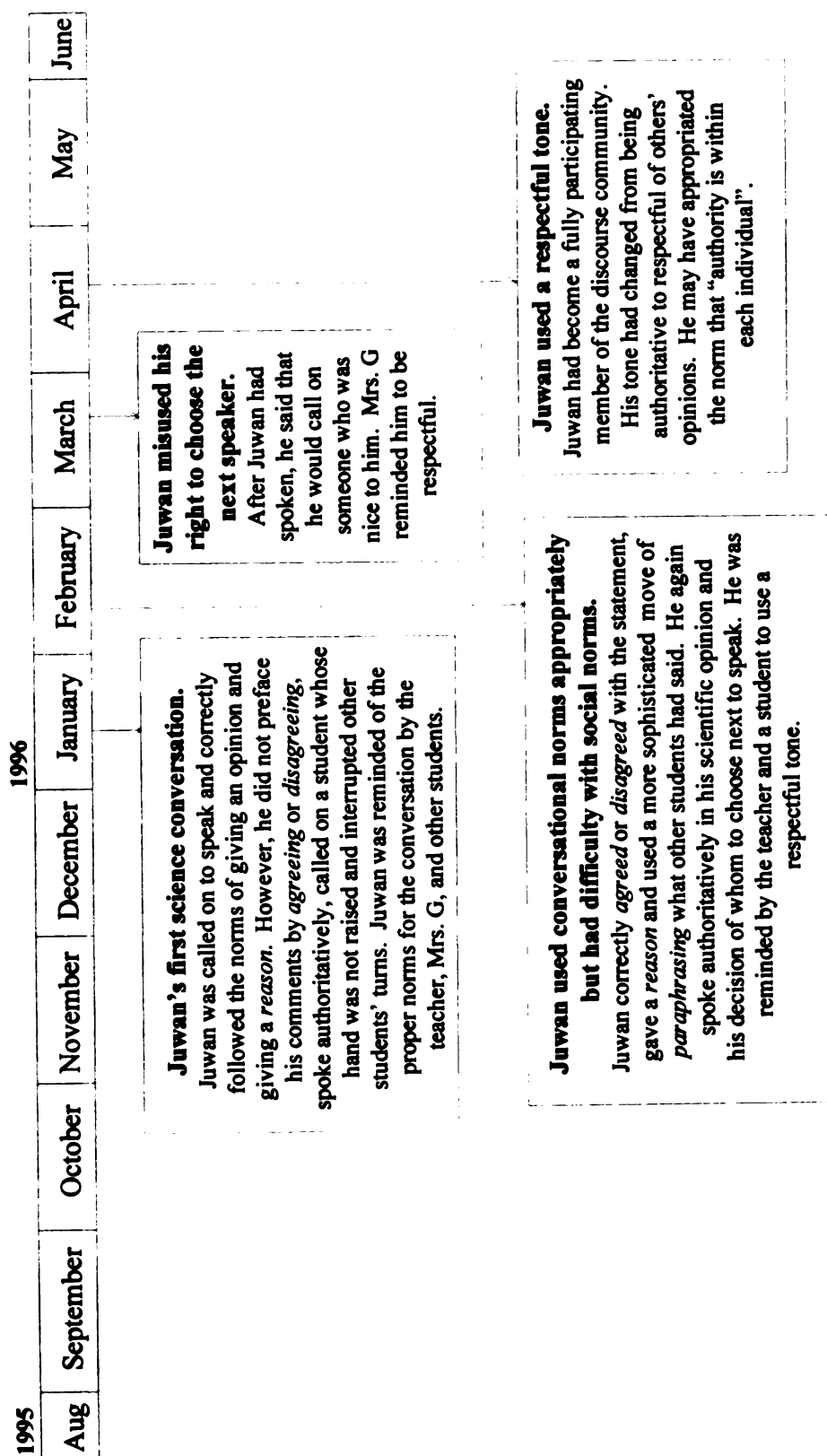


Figure 4.2 - Timeline of Juwan's Entry into the Classroom Discourse Community

Chapter 5

**KNOWLEDGE: CONVERGENCE/DIVERGENCE, GENDERED
CONSTRUCTION AND KNOWLEDGE SOURCES IN CIRCLE
CONVERSATIONS**

Introduction

In this analysis I considered knowledge, a construct that has been well developed in education research and practice. One relevant debate in the education community is whether convergence or divergence of knowledge should be a goal for students (AAAS, 1993; Barnes, Britton & Torbe, 1990; Denyer, 1993; Heath & McLaughlin, 1993; National Research Council, 1996; Warren, Conant, Ogonowski & Puttick, 1998). I examined the convergence and/or divergence and gendered construction of students' science knowledge along with their sources of knowledge in whole class circle conversations. I focused primarily on the development and progression of scientific knowledge along with knowledge connections students made among themselves. Within these conversations students had major autonomy for their particular content contributions within a given topic specified by the teachers. In addition, I was interested in better understanding the sources of knowledge that students drew upon in the conversations. I developed the following specific research objectives for this analysis.

1. Identify knowledge expressed by students in science conversations and its progression in terms of convergence or divergence.
2. Analyze the sources of students' expressed knowledge.

3. Ascertain patterns (by gender, topic and/or time) of students' knowledge expression and sources in the science conversations.

Theoretical Perspectives

This research began by examining the knowledge contributions of conceptual change research. Conceptual change researchers (e.g., Bishop & Anderson, 1990; Lee, Eichinger, Anderson, Berkheimer & Blakeslee, 1993; Posner, Strike, Hewson & Gertzog, 1982; Smith, 1990) successfully drew on and worked with students' divergent initial conceptions as a base from which they attempted to develop convergent, canonical scientific understandings. More recently, Heath and McLaughlin (1993) have studied knowledge as a narrowly convergent activity in terms of performance. In science, standards-based documents (AAAS, 1993; National Research Council, 1996) have argued for a set of common, convergent understandings for all students.

Sociocultural researchers have both reinforced (Edwards & Mercer, 1987; Howe, Tolmie, Duchak-Tanner & Rattray, 2000; Vellom & Anderson, 1999) and challenged (Barnes & Todd, 1995; Denyer, 1993; Keefer, Zeitz & Resnick, 2000; Rivard & Straw, 2000; Warren, Conant, Ogonowski & Puttick, 1998) the goal of school knowledge as convergent. Warren, Conant, Ogonowski and Puttick (1998) have recommended that we begin to pay more attention to the divergent knowledge expressed by students in science classrooms. Barnes, Britton & Torbe (1990) and Denyer (1993) have identified students' exploratory, rough draft talk as a fruitful space for knowledge expression and development.

Feminist philosophers have contributed to conceptions of knowledge by challenging us to look beyond traditional definitions of knowledge as objective, rational, abstract and universal (Hekman, 1990) and attend to its' situated, partial

(Haraway, 1996) contextualized (Hubbard, 1989) and subjective nature (Belenky, Clinchy, Goldberger & Tarule, 1986; Harding, 1986; Keller, 1985). They note the narrowly defined European male origins of the discipline and argue for a revisioning of science that includes other voices and knowledge bases such as personal experiences. Sociocultural researchers also address the situated and social nature of knowledge (Putnam & Borko, 2000). From this research perspective, Cunningham and Fitzgerald (1996) define three areas of knowledge that I will use in this study. These areas are “what can be counted as knowledge, where knowledge is located, and how knowledge increases” (p. 36).

Methods

I selected a subset of six out of 39 whole class science conversations for in-depth analysis of knowledge convergence/divergence, other knowledge patterns and students’ knowledge sources. The six conversations represented both classrooms and a range of scientific topics, student discourse forms and time periods during the year. Each conversation was transcribed, and a timeline was prepared organized according to speaker order. Abbreviated speaker comments were arranged in like groups according to content themes. Each timeline was further divided into two sections with the top half containing speaker comments and themes in *agreement* with the original topic statement and the bottom half containing comments and themes in *disagreement* with the topic statement. A speaker’s comments were placed in the *agree* or *disagree* section depending on the speaker’s own statements of agreement or disagreement. In a few instances, speakers shared comments without designating whether they were in agreement or disagreement with the topic statement or another speaker. In these cases,

I placed the comment in the *agree* or *disagree* area based on the context of the contribution. A sample portion of a timeline is shown in Figure 5.1.

These first extended timelines provided detailed maps of the conversations and allowed for analysis of convergence or divergence of topic claims and reasons in the conversations. Convergence was defined as the majority of speakers reaching consensus about a topic claim, and divergence was defined as the majority of speakers following multiple, differing lines of thought.

While the extended timelines provided a great deal of information about the convergence/divergence, progression and other patterns in the conversations, the maps in entirety were too large to fit on a conventional page. The maps were, therefore, modified to show their overall progression and thematic organization on one page. Numbers to indicate speaker order replaced speaker comments. An example of the first extended map (Figure 5.1) in abbreviated form is shown in Figure 5.2. In order to study potential gender patterns in the conversations, I prepared a duplicate set of abbreviated timelines with the speaker boxes color coded according to gender.

As I developed the timelines, I noticed relationships among the themes. Some themes seemed to derive from other themes. Some were complementary or in opposition to each other. As these relationships were not readily obvious from the chronological ordering of themes, I sought another representation to show the knowledge domains and relationships among themes developed by the students. I, therefore, created a concept map for each conversation (Novak & Gowin, 1984). I attempted to maintain each theme from the timeline as one idea expressed in an oval on the concept map. Like the timelines, the concept maps were divided into two halves. The top section contained concepts that were in *agreement* with the original topic

statement, and the bottom section contained concepts that were in *disagreement* with the original statement. The concept from the topic statement was placed in the center of the page. Like concepts were grouped together on the maps and color coded accordingly. The Roman numerals of the corresponding themes from the timeline were placed in the lower left region of the concept ovals. Solid black arrows linked concepts with a word describing the link next to the arrow. An example concept map based on the timeline in Figure 5.2 is shown in Figure 5.3.

Finally, I coded each student's comments according to the sources of knowledge expressed. Some students' contributions had multiple knowledge sources and were coded accordingly. Often, students stated their knowledge sources explicitly. At other times, sources were implied and could be discerned from the context of the students' comments. In a few cases, students did not express a knowledge source, and these comments were coded as no knowledge source.

Results

In the conversations the teachers presented the topic sentence as a universal claim and then asked the students to frame their contributions by first agreeing or disagreeing with the topic statement or another student's response and then giving a reason. The students' responses, therefore, were typically structured in two segments, a claim followed by a reason. The set of student knowledge claims and reasons within a conversation sometimes converged and, at other times, diverged.

Table 5.1 provides an overview of the conversations analyzed and summarizes the convergence and divergence findings. Two patterns concerning convergence and divergence were identified. Some conversations converged around a topic claim and diverged around the reasons. Other conversations diverged around both the topic claim

and reasons. In the construction and analyses of the timelines and concept maps, I found other more specific patterns related to depth and breadth of topic and gender construction of content. Some conversations with convergent claims and complementary, divergent reasons developed a depth of topic by progressing through increasingly complex concepts. Some conversations with divergent claims and divergent reasons developed a breadth of conversation by venturing on productive side trips related to but not directly focused on the initial topic claim. In all conversations, students often developed ideas in series of same gender turns producing a gendered construction of knowledge. In looking at knowledge construction by topic and time, there were no clearly discernable patterns.

Finally, students drew on a variety of informal and formal knowledge sources to express their opinions and reasons. Because of topical differences, these findings are reported as a whole and individually for each conversation.

Convergent Character

Convergent character is defined as the set of conversations in which the students' ideas converged around a topic claim but diverged around the reasons supporting that claim. Two conversations from Mr. K's class are used to illustrate this pattern. The first example gives the general characteristics of conversations with convergent claims with complementary, divergent reasons, and the second example shows how the seemingly divergent reasons are complementary and connected, increasing the depth of the topic by progressing through a series of increasingly sophisticated concepts.

Convergent Claims with Complementary, Divergent Reasons

During the middle of the year, Mr. K's class was studying space, and Mr. K presented the topic statement, "The sun is always shining," for the students' discussion. Throughout the conversation, students agreed with the statement as shown in the

abbreviated timeline in Figure 5.4.

Zan began the conversation by providing support for her agreement claim with the reason that the sun is on the other side of the earth when it is not shining on us. The next two speakers continued Zan's reasoning that the sun is on the other side of the earth at night (theme I) but also added to this idea with more reasons. The continuation of theme I and the addition of other themes is shown in the extended timeline in Figure 5.5 with exact transcripts of students' responses below.

Transcripts are shown in tabular form with speaker numbers and names for cross-referencing to the timelines in Figures 5.4 and 5.5. Girl speaker names are bolded, and boy speaker names are italicized. When a speaker expressed more than one reason, each reason was placed in a separate row corresponding to its theme. Nonverbal actions and author notes are placed in parentheses.

Speaker # And Name	Theme	Transcript
1. Zan	I	I agree with it (the statement) because when the sun isn't shining on us, it's on the other side of the earth.
2a. Sook-Joo	I	I agree with the statement because I learned from my brother that the sun is always shining because it's on the other side of the earth,
2b.	II	And at night, the moon is just covering the sun so it looks like... The moon is just in the sun's way.
<i>3a. Evan</i>	III	I agree with that because in the morning the sun comes up, and in the day, the sun is up, and in the evening, the sun is going down,
<i>3b.</i>	I	And in the night, I think the sun is on the other side, but it is still shining.
<i>3c.</i>	IV	It is reflecting the moon.

Both Evan and Sook-Joo included Zan's reason that the sun is on the other side of the earth at night (theme I) in their responses, but they did not stop there. They furthered the conversation by providing additional, complementary reasoning to Zan's original statement. The complexity of the reasoning grew as Sook-Joo and Evan introduced new

factors including relationships between the sun and moon (themes II and IV) and the specific movement of the sun over the course of a day (theme III).

Additional speakers continued this pattern of introducing new but related themes expanding the content of Zan's original reason. For example, speaker 4, Gary, extended the discussion of the moon's relationship to the sun by introducing a new theme that the moon is on the other side of the earth during the day (theme V).

Along with introducing new themes, most speakers echoed previous themes providing connection and confirmation with previous reasons. Speaker 5, Lucas, engaged in both moves as depicted in Figure 5.5, reaffirming Evan's point that the moon shines because of the sun's reflected light (theme IV). Lucas then extended the conversation with a new theme that when it is day here, it is night on the other side of the earth (theme VI).

Speaker 6, Kyubok, and the remaining speakers all restated Zan's reason (theme I) making it the most persistent theme in the conversation (Figure 5.4). Additionally, speakers 6 and 8 extended other themes (V and VI), and speaker 9 introduced a new, more encompassing theme that day and night are caused by the earth's rotation (theme VII).

Speaker # And Name	Theme	Transcript
6a. Kyubok	I	I agree with Evan (speaker 3) because when the sun is gone, it doesn't mean that the sun is not there because the sun is on the other side,
6b.	V	And the moon is on the other side.
7. Yue	I	I agree with the statement because when the sun's not shining here, the sun's on the other side...The sun is shining on Asia and Africa.
8a. Jill	VI	I agree with the statement because when it's daytime here, it's nighttime on the other side of the world,
8b.	I	And when it's nighttime here, it's morning in the other side of the world just like the time is different.

Speaker # And Name	Theme	Transcript
<i>9a. Preston</i>	I	I agree with the statement because if you're on the side that is facing the other face that is not facing the sun. It doesn't mean that the sun has stopped shining. It just means that the sun is on the other side of the earth.
<i>9b.</i>	VII	(Mr. K asks if the sun moved to the other side of the earth.) The earth was rotating.

The initial theme introduced by Zan that the sun is on the other side of the earth at night was restated by most of the speakers and was the most prevalent theme throughout the conversation. However, the students increased the depth of their reasoning by adding differing but complementary reasons to theme I. The conversation culminated in a global theme, theme VII, that day and night are caused by the earth's rotation. Theme VII encompassed the previously stated themes I, III and VI. Themes I, III and VI were, in fact, parts of the broader theme VII. Looking at the development of the conversation, it may have been helpful for the students' thinking to begin with more specific, particular reasons (themes I, III and VI) and build to broader, more general explanations (theme VII). This idea of beginning with discrete, partial reasoning and building toward more abstract, global reasoning is explored further in the next conversation.

Increased Depth through Concept Progression

In the previous conversation students developed multiple, complementary, divergent reasons to explain a convergent claim that the sun is always shining. The last speaker introduced a broad, encompassing theme (theme VII) about day and night that brought together previously stated specific themes (Figure 5.4). In conversation K3 at the end of the year, this pattern was more fully developed in a conversation beginning with the topic statement, "There is water in air."

The students began this conversation all agreeing with the statement and using similar reasoning (theme I) that water in air is invisible. The abbreviated timeline is shown in Figure 5.6.

Speaker # And Name	Theme	Transcript
1. Evan	I	I agree with that because you can't see it because it's invisible.
2. Lucas	I	I agree with the statement and Eugene that he's right that when water's in air, you can't see it, and it's invisible.
3. Kyubok	I	I agree with that statement because there is water in the air, but you just can't see it.
4a. Zan	I	I agree with the statement and with Eugene
4b.	II	Because, um, because water sometimes can be invisible.

Although Zan introduced a related theme (II) that water can *sometimes* be invisible, the conversation basically began on a surface level with little elaboration in the students' reasoning. The intern teaching the class, Ms. C, decided to probe the students' use and understanding of the word *invisible*.

Ms. C: A lot of you are saying that about the invisible. I'd like to ask you then, "How do you know it's there then?"

The next speaker, Yue, continued in the vein of the previous speakers but now changed the wording of *invisible* to *gas*.

Speaker # And Name	Theme	Transcript
5. Yue	III	I agree with the statement because when water's in the air, it's a gas.

Ms. C, still uncertain of the students' expression of their understanding, continued to push for more detailed explanations. The students struggled with fuller expression by exploring scientific terminology such as *gas*, *water vapor*, *steam* and *evaporate*.

Speaker # And Name	Theme	Transcript
Ms. C	III	Can you explain what the gas is to those of us who don't know?
6a. Lucas	IV	A gas is like steam or water vapor.
6b.	III	It's like Yue said.
7a. Sook-Joo	III	I agree with that statement because water is in the air. You just can't see it because it's a gas,
7b.	V	and, actually water that became a gas which is evaporated.
8a. Lucas	V	Um, what Sook-Joo was talking about,
8b.	VI	it rises up in the air, I'm just adding something to Sook-Joo's thing. When it's evaporating, it's in the air and going back to the clouds.

Even though Ms. C encouraged students to further their explanations, speakers 6 and 7 continued the pattern of previous speakers by offering a variety of different scientific terms to explain how water is in air. Lucas, speaker 8, however, shifted the conversation to a more concrete discussion of part of the water cycle by explaining that evaporation means "it rises up in the air" and is "going back to the clouds". By defining *evaporation* in terms of the water cycle, Lucas also provided an explicit connection to the prior simple, abstract explanations. The next speakers also offered more specific and tangible reasons by sharing real experiences with which the students could relate.

Speaker # and Name	Theme	Transcript
9. Gary	VII	Um, Ms. C, when you said, "Can someone explain this invisible thing? How do you know it's there?" Well, um, you can feel the air because blowing, and um, it's kind of wet, and you can feel it blowing in your face.
10. Lucas	VII	Like when you're cooking the rice in a rice cooker. The steam goes out of it, and you can feel it like wet.

Gary introduced a new theme (VII) that you can feel wetness from invisible water in the air blowing on your face, and Lucas elaborated this theme with a different example of feeling the wetness of steam from a rice cooker. Both speakers had shared concrete examples of life experiences with water in air as compared to the general explanations using abstract scientific terminology in the beginning of the conversation.

Evan next shifted the conversation back to the partial water cycle theme (VI) introduced by Lucas, speaker 8. Perhaps trying to connect the initial abstract reasoning with the recent, concrete explanations, Evan asked how water turned invisible. Gary, speaker 11, responded to Evan's query by returning to the water cycle.

Speaker # And Name	Theme	Transcript
11. Gary	VI	(Evan asks the question how water turns invisible.) Well, for one thing, you know when the rain stops, when the rain stops, it evaporates. It dries up, and it evaporates, and then it turns back into wind, I think.
12. Lucas	VIII	When it falls down from the clouds, when it's done raining, it goes into the ground, and then like after that, it evaporates up and goes into the sky again.
13a. Uchenna	I	I agree with the statement and Evan
13b.	IX	because even Jesus is like that. You can't feel Jesus.
14a. Jill	X	I think water is in the air, because my mom, wait, if there's too much water in the cloud, and it's sometimes the same with the body because there's a body part down here (points to stomach), and when it gets too full, you have to pee (students laugh).

Speaker # And Name	Theme	Transcript
14b. Jill	VIII	(Ms. C asks Jill to explain why water turns invisible.) When the water cycle goes around, the sun makes the water go up. Then it goes round and round, and it keeps evaporating,
14c.	XI	And sometimes the air has water in it, but you still can't feel it
14d.	XII	Because sometimes that's how you get water in the body when you breathe, and then it goes all the way inside your body, in your lungs, and it sometimes just stays there.

Other speakers also expanded upon Gary's response by introducing related themes. In addition, speakers 13 and 14 attempted to find analogies to explain water in air that the students could relate to like speakers 9 and 10 had done. While most students provided partial explanations of the water cycle in their reasons, Zan, perhaps synthesizing the previous speakers' comments, gave a full response explaining a complete cycle.

Speaker # And Name	Theme	Transcript
15. Zan	VIII	I agree with the statement, and also, I want to say something. When the cloud is full of water, it rains, and when it goes to the ground, it just splashes on the ground, and when the sun comes out, it's the water, it turns into one kind of gas, and then it, it evaporates back up to the cloud, and then there will be rain in another country.

While some students repeated the water cycle reasons with confidence of their explanatory power, others like Evan (who asked how water turns invisible) were still trying to connect the earlier abstract reasoning with the more recent concrete ideas. Yue followed with the question, "Is steam water?"

Lucas responded with the abstract terminology used by students previously. Not satisfied, Yue, with the help of Ms. C and the other students, strove for a concrete explanation in her next turn.

Speaker # And Name	Theme	Transcript
<i>17. Lucas</i>	XIV	It's water vapor.
18. Yue	XIV	Every time my mother cooks rice, steam comes out of the pot.
Ms. C	XIV	Is it coming from the water or coming from the rice?
Students	XIV	The water.

Kyubok, the next speaker, again revisited the partial water cycle explanation (theme VI), and Lucas then confirmed Yue's explanation that steam is water (theme XIV) with another real life example of steam coming from factories.

Speaker # And Name	Theme	Transcript
<i>19. Kyubok</i>	VI	I agree with that statement because the wind is sometimes, the clouds evaporate. The wind, um is like the water. So the wind goes up to the clouds.
<i>20a. Lucas</i>	XIV	Um, I think because when the steam's coming out of factories, it goes into the clouds, and there's water in the steam,
<i>20b.</i>	VI	So when the cloud gets too heavy, it falls.

The following speakers revisited the major explanations introduced in the conversation. Speaker 21 discussed the concrete experience of feeling water from the air on his hand (theme VII). Speaker 22 repeated the abstract reasoning of water evaporating into a gas (theme V), and speaker 23 detailed the full water cycle in his response (theme VIII). Finally, speaker 24 confirmed the prior assertion that steam is water with an example from her life experience.

Speaker # And Name	Theme	Transcript
24. Zan	XIV	I want to ask Yue a question. What was your question again?
Yue	XIV	Is steam water?

Speaker # And Name	Theme	Transcript
24a. Zan	XV	Oh, um, I have an answer to your question. Once, when my mom was cooking rice, she forgot to put water inside, inside our pot. So when we cooked it, no steam came out, but steam was supposed to come out, and then my mother saw that, um, she didn't put water in it,
24b.	XIV	So I think that water makes the steam.

Some students spoke or nodded their agreement with Zan providing a culmination to the conversation. In this analysis I have attempted to show how the students progressively built knowledge in the conversation through a series of partial, complementary themes that together provided a rich and comprehensive explanation of the topic claim. This complete set of reasons included abstract thinking with appropriate scientific terminology, specific concrete examples from life experiences and a holistic water cycle explanation that encompassed both the abstract and concrete themes.

The concept map of this conversation (Figure 5.7) emphasizes the development and connection of theme content as opposed to the chronological development of themes shown in the abbreviated timeline (Figure 5.6). Beginning with the center topic concept of water in air, the concepts immediately above it in light gray ovals represent the students' beginning discrete abstract explanations of water in air using the scientific terms: *invisible*, *gas*, *evaporated* and *water vapor*. This phase was followed by and connected to the partial and full water cycle themes shown at the top of the map in dark gray ovals. An important link between these two types of explanations occurred when Lucas stated that water *evaporated* to the *winds and clouds*. Amidst the partial water cycle explanations, students also shared specific, concrete examples of water in air from their life experiences. These concepts are

shown in white ovals at the bottom of the map. A particularly important example to the development of the conversation was the concept of *steam*. Initially, in theme IV, students treated *steam* as an abstract term seeing it as a replacement word for *gas*. However, when students discussed specific examples of steam in their lives, they reasoned that steam was water (white ovals in lower right area of map) especially with the help of Zan's powerful example of her mother cooking rice without water and seeing no steam.

The students created key links between the water cycle and abstract concepts and between the real life examples and abstract concepts. Because of these connections the students' expressed knowledge proceeded from a simple recitation of discrete scientific terminology to meaningful inclusion of abstract terms within specific contexts (steam from rice) and larger explanations (water cycle).

Divergent Character

Divergent character is defined as the set of conversations in which the students' ideas diverged around the topic claim and accordingly also diverged around the reasons supporting their claims. Two conversations from Mrs. G's class are used to illustrate this pattern. The first example gives the general characteristics of conversations with divergent claims and reasons, and the second example shows how the students can take productive side trips as they pursue ideas related to the original topic claim.

Divergent Claims with Divergent Reasons

In the beginning of the year, Mrs. G discussed the topic statement, "All plants die in the winter" during a plant unit. The first three students agreed with the statement, and the conversation began in a similar way to the first convergent

conversation about the sun always shining. Figure 5.1 shows the beginning phase of the extended timeline.

The first speaker Audrey shared a personal experience of a plant outside dying in the winter (theme I). Nimah then agreed with the statement (theme II) but did not share a reason. Boseda, speaker 3, continued Audrey's theme of plants outside dying in winter with a personal experience of his own (theme I) and then introduced a new idea that he had to plant a new plant (theme III).

The next three speakers introduced entirely new reasons creating multiple divergent paths for the conversation as shown in Figure 5.1.

Speaker # And Name	Theme	Transcript
4. <i>Manuel</i>	IV	I disagree because in Mexico, no plants die in the winter.
Mrs. G	IV	What's winter like in Mexico?
4. <i>Manuel</i>	IV	It doesn't snow. You don't have to wear snow boots. You can wear tennis shoes.
Mrs. G	IV	But all the plants live? Do they change at all?
4. <i>Manuel</i>	IV	Well, at least their flowers fall off, but they're still alive.
5. <i>Darweshi</i>	V	I agree that all plants die because like, when snow comes down, it hits the, it hits the like, it hits the plant, and in the plant, and the plant, and it falls down because the snow is harder than the plant, so it, so when it hits the plant, the plant goes down.
6. Hasima	VI	See, I, I, plants don't die in the winter. (Mrs. G asks for a reason.) Because if the snow is like a blanket, and it protects it from the storms and things.

Manuel, speaker 4, was the first student to disagree with the statement and cited his experience living in Mexico where no plants die (theme IV). Darweshi and Hasima then reverted to talking about Midwestern type winters with snow, although they had opposing ideas about how snow affects plants (themes V and VI).

Perhaps feeling confused about the different contexts discussed, Audrey, an African American student, made a bid to limit the discussion to American winters.

Mrs. G carefully considered Audrey's request and suggested that future speakers make an explicit statement of the context they were discussing.

Speaker # and Name	Theme	Transcript
7. Audrey	IV, VI	I disagree with Hasima and Manuel because Hasima's talking about their country, and Manuel is talking about Mexico.
Mrs. G	IV, VI	So what do you think we should talk about?
7. Audrey	IV, VI	America.
8. Mrs. G	IV, VI	Think so? When it's your turn, can you say, "I'm talking about all plants in America," and when Manuel talks, can he say that he's talking about all plants in Mexico and just change it a little bit. (Audrey nods yes.) That's okay? Sure. (This comment of Mrs. G's is numbered and included as part of the knowledge analysis because she made a substantive contribution to the conversation stating that future speakers should specify what country they are talking about. Her comment may have directly influenced the substantive content of later speakers who explicitly talked about plant growth in their own countries. Typically, teachers provided guidance mainly in helping students to manage the conversations but did not offer substantive opinions on the topic themselves. Therefore, most of the teacher comments were not numbered nor directly included in the knowledge analyses.)

By allowing the multiple, divergent comments, Mrs. G signaled to the class that a divergent conversation was acceptable as long as the students' contributions were relevant to the topic at hand. However, Mrs. G also respected Audrey's implication that trying to make sense of the multiple contexts was confusing. Audrey may have wanted to steer the conversation into a convergent path that would have been easier to follow and understand. Mrs. G, though, realized the importance of students sharing all relevant ideas for the topic including their personal experiences. As many of the students in the classroom were international, much of their experiences with seasonal plant changes came from observations in their home countries. Mrs. G valued the

multiple and varied knowledge that the students brought with them and saw the sharing of this knowledge as a way to broaden and enrich the conversation. Mrs. G showed her own interest and enthusiasm about seasonal plant changes in other countries with her questions to Manuel (speaker 4) asking him to say more about what happened to plants in winters in Mexico.

After this exchange the next speakers shifted back to a pattern like the beginning of the conversation where they agreed with the statement and provided some new reasons along with continuing previous themes (Figure 5.2, abbreviated timeline).

Speaker # And Name	Theme	Transcript
9a. Steven	V	I agree with Darweshi
9b.	VII	But there is one thing that he just forgot. The wind can blow it down, too, when it's fall time. So some plants die.
10a. Darweshi	VII	I disagree with you (Steven)
10b.	V	Because if the, if the, um, if the,
Mrs. G	V	snow?
10b. Darweshi	V	snow covers the flower, and then lightning strikes it. Then the snow will break, and the flower will, um, the flower won't break.
Mrs. G	V	The flower won't break?
10b. Darweshi	V	Yeah, and the snow will break... The snow, the snow will break and melt, and then the flower will break.
11a. Nina	I	I agree with Audrey. All plants,
11b.	VIII	some plants die in the winter.

Steven (speaker 9) agreed with Darweshi's reason (speaker 5) that hard snow makes plants fall and die (theme V) and then added a new reason that wind in fall blows and can make some plants die (theme VII). While Darweshi (speaker 10) claimed to disagree with Steven, possibly with Steven's reason about the wind (theme VII), Darweshi then went on to elaborate his previous reason about hard snow making plants fall and die (theme V). Nina referred her agreement back to the first speaker

Audrey (theme I) but then changed the degree of the original claim by stating that *some* instead of *all* plants die in the winter (theme VIII).

The conversation continued in this vein with the next students agreeing with the original topic claim until Mila, speaker 15, shared a number of reasons for plants dying or staying alive.

Speaker # and Name	Theme	Transcript
15a. Mila	VIII	I agree that it dies in winter,
15b.	IV	But some places near the equator, they don't die.
15c.	X	If you don't put any water, they will die.
15d.	XI	If you put enough water, they won't die.

Along with affirming the reasons that *it* (some plants) dies in the winter (theme VIII) and that plants do not die in the winter in some countries (theme IV), Mila also addressed the issue of water being important to a plant's life (themes X, XI). The remaining speakers continued to affirm prior reasons but also introduced a variety of new reasons like Mila, in agreement and disagreement with the original claim that all plants die in winter (Figure 5.2). The final students' comments were as follows.

Speaker # and Name	Theme	Transcript
19a. Unika	II	I kind of agree
19b.	XIV	and disagree 'cause when it's winter, I'm going to check if the plants really grow, or, if they really die 'cause I don't really know if they will grow.
20a. Dong-Yul	XV	(Mrs. G asks if he thinks all plants die in the winter.) No, not a bit. Um, (Mrs. G asks for a reason.). What about in other countries, can I?
Mrs. G	XV	Sure.
20a. Dong-Yul	XV	Um, all plants doesn't die in my country because I don't know... In my country when snow comes, it looks almost like America. It's really different.
Mrs. G	XV	What country is that?
20a. Dong-Yul	XV	Korea, but it, and when it snows, sometimes it doesn't die,
20b.	XVI	And sometimes it does die.

Speaker # And Name	Theme	Transcript
21. Ellen	XVI	In my country, in the first place where I was born, it was near the mountain. It snowed there. I put a plant up on the mountain with my dad. I put a plant up there, and when I came back, I found it dead. When we moved, I put another plant there. It died.

Unika introduced a new theme (XIV) of planning an investigation when winter came to determine if plants lived or died. He may have been listening to the many divergent reasons and decided a first-hand experiment was the best way to test the claim. Asking permission from Mrs. G, Dong-Yul also talked about plants in his own country of Korea surmising that sometimes they do die (theme XV), but others do not die (theme XVI). Ellen continued Dong-Yul's theme of some plants dying in some countries (theme XVI) with a personal experience of putting plants on a mountain with snow.

The conversation ended with Ellen's contribution and no consensus on whether or not all plants die in the winter. However, the students had clearly addressed the topic along with a multitude of related issues (all vs. some plants, weather, water, location, investigations and new plants). The students showed that a number of factors need to be considered in determining whether plants live or die in the winter and in other seasonal conditions. The students' contributions illustrated the richness of their understanding and the complexity of the topic when they deeply probed the broader meaning of the original statement. The entire set of students' comments show how divergent conversations can be productive. The students pushed beyond the surface meaning of the topic statement with fuller responses including an array of reasons which meaningfully expanded the breadth of the conversation.

Increased Breadth through Productive Side Trips

In the middle of the year, Mrs. G's class again engaged in a divergent conversation around the topic questions, "When did dinosaurs live?" and "Did they all live at the same time?" Unlike the previous conversation in which students brought up a number of different issues directly related to the topic statement, the students here pursued a number of issues in a different topic, a related and productive side trip, from the original questions given by Mrs. G.

Figure 5.8, the extended timeline for the first phase of the conversation, shows the variety of themes introduced by the beginning speakers. Audrey (speaker 1) began the conversation by disagreeing with the topic and stating that she knew dinosaurs lived in three different time periods (theme I) from a game she had at home. (Mrs. G had recently begun using topic questions in addition to topic statements. Audrey's disagreement with the question may have been due to her previous experience with the format of agreeing or disagreeing with a statement.) Unika (speaker 2) then continued the agree/disagree format by agreeing that "dinosaurs lived a long time ago" (theme II). He added a second claim that "nobody was born" (theme III) which began a persistent side trip focusing on human existence and form at the time of dinosaurs. Darweshi (speaker 3) picked up on Unika's second comment and agreed with him (theme III).

The fourth speaker, Juwan, returned to the topic questions and the beginning themes (I and II) introduced by Audrey and Unika. He then added a different but related point that some dinosaurs were meat eaters, and some were plant eaters (theme IV). He-Ping (speaker 5) returned to the topic question as well (theme II) but then responded to Darweshi's comment (speaker 3) agreeing that humans were not alive at the same time as dinosaurs (theme III). He-Ping provided further explanation as to

how humans came to be. First, dinosaurs became extinct (theme V). At the time of dinosaurs, humans were monkeys (theme VI), and then humans “grew up” to be humans (theme VII). The next speakers (6-8) continued to address the new themes (V and VI) related to human form at the time of dinosaurs (Figure 5.8).

Speakers 9 and 10 (Figure 5.9) made an attempt to return to the original topic themes (I and II), and Mila (speaker 9) introduced a new theme (VIII) related to Juwan’s (speaker 4) earlier theme about meat eaters and plant eaters (theme IV).

Speaker # and Name	Theme	Transcript
9a. Mila	II	I think that dinosaurs lived a long time ago,
9b.	I	and they, some lived at different times, and some didn’t. (Mrs. G asks Mila if she said different times, and Mila nods yes.)
9c.	VIII	And I think the dinosaurs were the plant eaters were separated, and the meat eaters were a relative (rest inaudible)
Mrs. G	VIII	By time?
9c. Mila	VIII	Yeah.
10. Alisha	I	I think dinosaurs were not born at the same time.

The next set of speakers (11-13) again addressed the new topic, human existence and form at the time of dinosaurs (theme VI). They all agreed with a previous speaker Nimah (speaker 7) who had stated that there were cave men or cave people, not monkeys, alive at the time of dinosaurs. Though Ellen (speaker 13) agreed with Nimah and Audrey (speaker 11), she wondered about the relationship between people and monkeys.

Speaker # and Name	Theme	Transcript
11. Audrey	VI	I agree with Nimah because of I read a true story that there was cave men, cave people at the time of dinosaurs.
12. Alisha	VI	I agree with Nimah because the cave men were born when the dinosaurs were born.
Nimah	VI	Cave people (gender correction).

Speaker # and Name	Theme	Transcript
12. Alisha	VI	Cave people.
13. Ellen	VI	I kind of agree with Nimah and Audrey because there's a story I have at home, and it showed people that didn't wear clothes. They had long beards. They looked like monkeys. I think they looked like monkeys.

Darweshi (speaker 14) returned to the theme of meat eaters being separated from plant eaters (theme VIII) introduced by Mila (speaker 9), but the next set of speakers (15-18) again continued the topic of humans at the time of dinosaurs.

Speaker # and Name	Theme	Transcript
<i>15a. He-Ping</i>	III	I agree with Darweshi (theme III) and Unika and disagree with Nimah and Alisha (theme VI) because how can cavemen, I know that the real truth is that people and dinosaurs did not live at the same time...
<i>15b.</i>	VI	Cavemen were not even lived at the same time. It was the one who, no one, you guys (to girls) just watch fantasy movies because how can cave people be at the same time as dinosaurs? And Darweshi (theme III) and Unika (theme VI) was the only ones who were correct.
<i>16a. Steven</i>	VIII	Well, I disagree with that because God made the plant eaters first. Then he made the meat eaters
<i>16b.</i>	III	before the two people were living.
17a. Mila	VI	I think that I agree and disagree that I'm not really sure that cave people were living, but I, the cave people started the stories that it's about dinosaurs that have cave people on it. I think it's fake.
17b.	III	And that's because dinosaurs, I know that humans or people, not even one person lived when dinosaurs lived.
<i>18a. Juwan</i>	VI	I disagree with her (Mila) and He-Ping because for one thing, talking about dinosaur movies, for one thing, I read a book that it said, the name of the book was <u>Real Stories about Dinosaurs and People</u> . Cavemen looked like monkeys, but mon, but they were not monkeys, no
Mrs. G	-	What does that have to do with the dinosaurs?
<i>18a. Juwan</i>	VI	Dinosaurs, see, the dinosaurs, the dinosaurs were in there, but it said the dinosaurs were living. People were living, but they were cavemen, no women.
<i>18b.</i>	IX	And, um, and no animals. I mean NO ANIMALS. Not monkeys, not tigers, not lions. There were no animals.

Both He-Ping (speaker 15) and Mila (speaker 17) questioned the knowledge sources of the students who claimed that humans were alive at the time of dinosaurs (theme VI). Juwan (speaker 18) countered their questioning by attempting to reference a valid knowledge source, a book entitled Real Stories about Dinosaurs and People. In the midst of this debate, Steven (speaker 16) first addressed plant eaters and meat eaters (theme VIII) and then referenced a religious source (God and the creation story) as evidence that humans were not alive at the time of dinosaurs.

Mrs. G provided some boundaries to the human side trip by asking Juwan to relate his comments to dinosaurs. Mrs. G then explicitly prompted Dong-Yul, speaker 19, to address the topic question by repeating it prior to his turn. Boseda, speaker 20, however, ended the conversation on the new topic of human existence at the time of dinosaurs by challenging Juwan's knowledge source of a book.

Speaker # and Name	Theme	Transcript
Mrs. G	-	Dong-Yul, do you think all dinosaurs lived at exactly the same time or different periods?
19. Dong-Yul	I	No, some lived at the Jurassic, and some lived at the different time, and some lived almost with the night time, and some almost lived when there were, when the asteroid hit at the earth...
20. Boseda	VI	I just want to tell Juwan (speaker 18) that I agree, I mean I disagree because some books are not, not (pause)
Mrs. G	VI	Accurate? (Boseda nods yes.) Juwan, we were finding out earlier that not even all books even agree, that different authors have different opinions. That's what he's sharing because you weren't here when we found that out, but go on (to Boseda).
20. Boseda	VI	Some books are.

Boseda, like other students, attempted to verify or discredit claims about human form and existence at the time of dinosaurs by questioning sources of knowledge (books, movies and stories) provided. In this conversation, the students showed that

not only was the substance of claims and reasons important to their decisions in accepting or rejecting ideas. They also needed to know the source of the knowledge shared to determine if it was valid or not.

The shifts between the original topic of times when dinosaurs lived and the new topic of human existence and form at the time of dinosaurs show students' attempts to stay on track with the given topic but also their unwavering interest in pursuing a related question. The prevalence of the human related themes indicates the curiosity students had with this topic. Looking at Figure 5.9, one can see the number of comments and persistence of the human existence themes (III, VI, VII and IX). Fewer but multiple contributions (themes I and II) throughout the conversation were addressed to the original topic. A few comments (themes IV and VIII) were addressed to a side topic of plant eaters and meat eaters, a topic which had been discussed in school science lessons outside of this conversation.

The concept map (Figure 5.10) of this conversation also shows the predominance of the topic of human forms of existence at the time of dinosaurs (white ovals). The themes related to the original topic of the time periods of dinosaurs are shown in dark gray ovals. All of the themes could be related back to the original topic statement. However, it was clear from the preponderance of comments regarding humans that this was a topic students were interested in and had strong ideas they wanted to share.

Seeing the students' interest, Mrs. G. allowed the students to develop this side topic. In so doing, they broadened the concept of dinosaur time periods to include or not include humans. Their interest in humans may have been due to a developmental stage focused on self (Osborne & Freyberg, 1985). However, in considering human

existence, students also explored complex, contrasting ideas of human evolution including human development from monkey-type ancestors, present-day human form from cave people ancestors and the biblical interpretation of Adam and Eve as the first humans. Clearly, from the tone of the conversation, these were important, emotional issues about which the students were wondering. This conversation allowed them to express and hear others' ideas on a topic which they thought deeply about but which was not a part of their formal curriculum.

Mrs. G's encouragement and tolerance of related ideas gave students an opportunity to meaningfully expand the breadth of their knowledge about when dinosaurs lived to a larger question of how humans fit into the history of the earth. What was human life like at the time of dinosaurs? If humans did not live then, when and how did they originate and develop? This conversation shows the complexity of students' thinking when they are given an opportunity to express many of their ideas as had been done here by Mrs. G. It also shows students' attempts to put a concept (time periods of dinosaurs) into a broader framework of knowledge (history and relations of humans with dinosaurs).

Gendered Construction of Knowledge

In both the convergent and divergent conversations, a clear gendered pattern was identified in the construction of knowledge. Within the larger patterns of convergence and divergence, same gender students developed smaller convergent but elaborated clusters of knowledge. Often, the *gender clusters* of content for one gender were in opposition to the content developed by the other gender. This pattern contributed to divergent conversations. Even within convergent conversations, girls' comments were often clustered and separated from boys' clusters of comments. This

pattern of gendered construction of knowledge was apparent through both the theme development of the content and the references to previous speakers (discussed further in knowledge sources).

Gendered Knowledge Construction in Convergent Conversations

Figure 5.11 depicts the abbreviated timeline for a convergent conversation (K1) in Mr. K's class at the beginning of the year which illustrates how knowledge construction was often influenced by the gender of the speakers. In this example, Mr. K chose the first speaker Sang-Ook (a boy) who agreed with the topic statement, "Sight is more important than hearing" (theme I). Sang-Ook then chose another boy, Evan (speaker 2), who disagreed with the statement (themes II-IV). Evan began a pattern in which a series of boys (speakers 2-5) all disagreed with the statement but also agreed with the immediately previous boy speaker. An exact transcript of the beginning of conversation K1 shows the pattern of gendered knowledge construction as the boys (speakers 2-5) successively agreed with each other and collaboratively developed the content (themes II-IV).

Speaker # and Name	Theme	Transcript
1. Sang-Ook	I	I agree because, um, because if you want to say something, you can write it on a piece of paper. When other people are talking to you, they can write it on a paper, and you can read it (rest inaudible).
2a. Evan	II	I disagree with the statement because I think they're both the same? (Mr. K asks Evan why he thinks they are both the same.)
2b.	III	Um, because we could see if there's a car coming, and you won't get run over.
2c.	IV	And you can hear the cars coming with the honker.
3a. Arshad	II	I agree with Evan because, um,
3b.	III	you can see strangers passing by,

Speaker # And Name	Theme	Transcript
3c. <i>Arshad</i>	IV	Or when your friend wants to say something, and you want to know how to play it, then you might not remember. You might not remember. You might not hear anything, and you will just play the game, and you will be out or something.
4a. <i>Irving</i>	II	I agree with <i>Arshad</i>
4b.	V	Because if you didn't, if you couldn't see or hear, a stranger could just pick you up, and you wouldn't even know.
5. <i>Isaac</i>	II	I agree with <i>Irving</i> because, because, um (pause), I forgot what I was going to say.

Evan (speaker 2) shared his disagreement with the statement (theme II) and provided reasons why sight (theme III) and hearing (theme IV) are important. Arshad (speaker 3) followed by agreeing (aligning) with Evan (theme II) and collaboratively developing the reasoning with different examples but along the same content lines (themes III and IV). Irving, likewise, agreed with Arshad (theme II) and further developed the reasoning by providing a single example in which the lack of both sight and hearing could create dangerous situations (theme V). Isaac continued the pattern by agreeing with Irving (theme II) but then forgot his reason. The ideas showed topical cohesion and may have reached a point of full development for Isaac. The next boy speaker Yat-Sen (speaker 6) then continued developing the content of sight and hearing being important (themes III and IV) but broke the pattern of explicit gender alignment by not referencing a previous boy speaker.

Yat-Sen also broke the gender turn taking pattern by calling on a girl in which a series of girl turns (speakers 7-15) then ensued. As with the boys, the girls developed patterns of gender alignment (girls calling on and agreeing with previous girls speakers) and collaborative development of the floor (expanding the reasoning of the

previous girl speaker). A section of the transcript beginning with Natalie's turn (speaker 8) and ending with Alexandra's turn (speaker 12) follows.

Speaker # And Name	Theme	Transcript
8. Natalie	I	I agree with the statement because, um, if you didn't, you couldn't hear (pause), if you couldn't hear, your friend could write a statement that she wanted to tell you or something, and you could see it.
9a. Jill	III	I agree, I agree
9b.	IV	and disagree with the statement.
9a.	III	I disagree with the statement because if you were driving, if you were driving, you couldn't see where you were going, and, and you couldn't see, and you wouldn't know where you were going. (These comments were placed in the "agree" section because they deal with the part of the topic claim that "sight is important").
9b.	IV	And if you couldn't hear, if you were walking on the train tracks, and somebody was trying to tell you that a train was coming, you wouldn't know because you would just think that everyone was waving at you.
10a. Sook-Joo	III	I agree
10b.	IV	And disagree because, um, I agree and disagree because, um, that
10a.	III	because if you didn't have hearing (probably means sight), you couldn't see somebody writing or somebody could just write it on a paper and let you know what they were trying to say.
10b.	IV	And I disagree with the statement because if you didn't have hearing, you wouldn't really be able to see what they mean. Like Jill said, you would just think that the people might be just waving at you.
11a. Jennifer	III	I agree with Sook-Joo because if someone was walking with you, and you can't hear, then you can just walk behind, and then they will see them.
11b.	IV	And I disagree because sometimes when you can't see, and you can only hear, you can hear a car, and then you stop. And then you go on the sidewalk when the car's over, and then there might be another car, and then you start running and running, and you bump on the sidewalk.
12a-b. Alexandra	III IV	I agree with Jennifer.

Natalie (speaker 8) did not align with the previous girl speaker, but in her reasoning, she did refer to a female friend thereby making a gender affiliation. Jill (speaker 9) then agreed (theme III) and disagreed (theme IV) with the statement, beginning a series of gender alignment and collaborative development of the floor that included girl speakers, Sook-Joo, Jennifer and Alexandra (speakers 9-12).

Jill and the girl speakers following her both agreed (theme III) and disagreed (theme IV) with the statement. When giving her reasons, Jill told of a time (driving) when a person would need sight. She then told of a time when a person would need hearing (a train coming with people waving danger that is not understood because a person could not hear). Although Jill tagged her example of a driver needing sight as a disagreement with the statement, this point was coded as agreement because she addressed the idea of "sight being important" (theme III). She never explicitly stated how her comments were in agreement with the statement. However, her point about sight corresponded better with the original topic statement than her second point of "hearing being important" which was coded as a disagreement (theme IV). The girls followed a similar pattern to the boys of providing examples both of sight being important (theme III) and hearing being important (theme IV). However, there was a difference in the responses as the boys saw both points as a disagreement with the original statement (themes III and IV), and the girls saw the point of sight as agreement (theme III) and the point of hearing (theme IV) as disagreement with the original statement. Therefore, theme III, which was placed in the *disagree* section for the boys' comments was moved to the *agree* section when the girl speakers both agreed (theme III) and disagreed (theme IV) with the topic statement.

Following Jill, Sook-Joo (speaker 10) also agreed and disagreed giving examples of when someone would need sight (theme III: if someone was writing on a piece of paper) and hearing (theme IV: referenced Jill's comment about a person waving at you). Jennifer (speaker 11) followed the pattern set by Jill and Sook-Joo in agreeing and disagreeing with the statement and providing examples of when sight (theme III) and hearing (theme IV) are important. Alexandra (speaker 12) agreed with Jennifer but did not expand upon her reasoning in a similar way to Isaac (speaker 5) in the previous transcript. Again, the collaborative development may have run its course, and she may have thought the ideas were fully developed.

As with the boys, this end to the pattern of gendered construction of knowledge signaled a shift in the conversation. The next speaker Jill (speaker 13) disagreed (themes I and IV) with the first boy speaker, Sang-Ook (theme I).

In comparing the construction of knowledge among the girls and the boys, there were two separate clusters comprised of a succession of same gender turns (speakers 2-5 for the boys and speakers 9-12 for the girls). In each gender cluster the students aligned with each other according to the topic statement and/or previous speaker. In the case of the boys, the students *disagreed* with the topic statement or *agreed* with each other. The girls both *agreed* and *disagreed* with the topic statement and/or *agreed* with each other.

In both gender clusters, the students collaboratively developed a rich and diverse set of examples as reasons to support their claims. In their disagreement with the topic statement, the boys expressed the opinion that sight (theme III) and hearing (theme IV) are equally important. Then they mainly gave examples of potentially dangerous situations (car running a student over or a stranger picking up a student) in

which sight or hearing would be essential in preventing the danger from happening. The girls also shared examples of the lack of sight (theme III) or hearing (theme IV) causing danger (train coming at a person or a car approaching a person) along with other less physically dangerous examples involving difficulties with communication (someone writing on a paper or walking with another person). One boy, Arshad (speaker 3), also gave an example of difficulty in communication (not being able to understand the operation of a game). While each gender cluster had similarities in content and alignment with previous same gender speakers, they were framed differently in relation to the original topic statement (*disagreement* for boys and *agreement* and *disagreement* for girls). Though the framing of the topic was different according to gender, the content of most of the speakers' contributions was essentially along the same line. Most students thought that sight and hearing were equally important. The overall conversation, therefore, was coded as convergent.

Gendered Knowledge Construction in Divergent Conversations

Figure 5.12 shows similar patterns of gender alignment in the construction of knowledge in a divergent conversation (G3) in Mrs. G's classroom at the end of the year. The students were discussing the statement, "Air has a color." As in Mr. K's class, a series of boys' turns resulted in gender alignment and collaborative development of the floor. The first series began with Jason (speaker 1) disagreeing with the statement that air had a color because he could not see any color (theme I). Jason then called on Unika (speaker 2) who agreed with him (theme I) and expanded the reasoning (theme II) followed by Darweshi (theme I).

Speaker # and Name	Theme	Transcript
1. <i>Jason</i>	I	I disagree. (Mrs. G asks him why.) ...I don't see any color.
2a. <i>Unika</i>	I	I agree with <i>Jason</i> because air doesn't have a color. It's like you can't see it, and there's no color. It's kind of like invisible, but I agree that there's no color.
2b.	II	It's just like white.
2a.	I	You can't see it.
3. <i>Darweshi</i>	I	I agree with <i>Unika</i> because there's air in this room, and I agree with <i>Jason</i> . There's air in this room, but we cannot see the color because when you walk around, and you can see air in the sky. There's air every you can find it, and when you kind of look up, there's no air. It's like it's invisible.

Darweshi (speaker 3) agreed with both Unika and Jason and elaborated the reasoning to include the lack of color in air in the room and air in the sky (theme I). Unlike the beginning of the year conversation (K1) in Mr. K's class, the students now tended to reference all of the previous speakers in the collaborative development of the floor rather than just the immediately preceding speaker.

Mrs. G next broke the boys' turn taking pattern and gendered construction of knowledge by asking Darweshi to choose Mei-Hua as the next speaker.

Speaker # And Name	Theme	Transcript
Mrs. G	-	Would you please call on Mei-Hua because she hasn't had any turns? Mei-Hua, do you agree with Darweshi that air has a color or doesn't have a color?
4. <i>Mei-Hua</i>	I	Agree.
Mrs. G	I	You agree with him that air has no color. Do you want to tell anything about why you think so?
4. <i>Mei-Hua</i>	-	No.
Mrs. G	-	No, okay. Darweshi, go ahead and call on somebody else then.

Mrs. G actually called on Mei-Hua herself and proceeded to ask Mei-Hua's opinion. Mei-Hua was a quiet student who did not often speak in the science

conversations. Mrs. G attempted to facilitate her entry into the conversation by giving Mei-Hua additional teacher support. Interestingly, Mrs. G framed her question to Mei-Hua as agreement or disagreement with Darweshi rather than the topic statement. Mei-Hua continued the topic alignment by agreeing with Darweshi but did not add any reasoning to contribute to the construction of knowledge. Possibly because the teacher chose Mei-Hua, Mrs. G gave speaker rights back to Darweshi. Mrs. G may have been implicitly modeling the choosing of different gender speakers as suggested by a later move. Darweshi, however, did not choose to pick a girl, and instead picked another boy Justin (speaker 5).

Speaker # And Name	Theme	Transcript
<i>5a. Justin</i>	I and II	I disagree with <i>Unika</i> , <i>Darweshi</i> and <i>Jason</i> and Mei-Hua
<i>5b.</i>	III	Because air has a color.
<i>5c.</i>	IV	When you go outside, you see that up in the sky, there's blue. That's the color of the air. (Students start to talk and disagree with Justin.)
Mrs. G	-	Wait, wait, you're not to argue with him. You, I think you understood what he said because that's why you started arguing. So if you want to respond, you raise your hand when he calls on somebody, and I think it's time to call on a girl because I see that we have, four or five boys had turns
<i>5. Justin</i>	-	(interrupting) <i>Unika</i>
Mrs. G	-	In a row.
<i>Unika</i>	-	Aw, a girl.
<i>5. Justin</i>	-	Audrey.

As with Mr. K's class, the pattern of collaborative development of the content by Jason, Unika, Darweshi and Mei-Hua was broken after a brief series of turns. Possibly Mrs. G's facilitation of Mei-Hua's turn or Mei-Hua's statement without a reason signaled the shift. Although Justin (speaker 5) broke the collaborative development of the floor and agreed with the statement, he still referenced all of the

previous speakers. It seemed important to the speakers to acknowledge individual ownership of previous opinions.

Mrs. G made an explicit move to shift the gender of speakers following Justin's turn. There appeared to be some resistance as Justin first called on a boy, Unika. Unika voiced disappointment at the gender shift even though he had had a turn previously. Justin then followed Mrs. G's suggestion and chose Audrey as the next speaker.

Speaker # And Name	Theme	Transcript
6a. Audrey	IV	I disagree with <i>Justin</i>
6b.	V	because blue is the color of the sky, not the air. (Mrs. G responds that Audrey's comments were clear.) Ellen, what do you think?
Alisha	-	She didn't raise her hand.
7a. Ellen	VI	Um, part of, um, sometimes in the fog, the air has color. It's white,
7b.	VII	but usually air doesn't have color.
8a. Alisha	V	I agree with Audrey
8b.	VII	and Ellen ,
8c.	IV	and I disagree with <i>Justin</i> ,
8a.	V	Because blue is the sky,
8d.	I	And see, the air doesn't have any color. I think the air doesn't have any color because (pause) because if we don't have air, I think (Alisha again pauses, and Mrs. G asks her to keep thinking about her idea and call on someone else.)

Like Justin, Audrey (speaker 6) may have tried to keep the floor for the girls by next choosing a girl, Ellen (speaker 7), who did not have her hand raised. Audrey may have been using her authority as speaker to include Ellen as she had often raised her hand previously without being called on until the end of the conversation after most other students had had a first turn. Alisha vocalized this breaking of the norm, but Ellen took the opportunity to speak and was ready with complex reasons (themes VI and VII) implicitly agreeing and disagreeing with the topic statement by saying that

sometimes air had a color (as in fog), but usually it did not. Alisha and other speakers then further developed this reasoning.

Like Darweshi (speaker 3) and Justin (speaker 5), Alisha referenced multiple speakers agreeing with the girls and disagreeing with the boy, Justin. Anita (speaker 9) and Boseda (speaker 10) also aligned with the previous girl speakers and collaboratively developed the idea that air can sometimes have color (theme VI) and sometimes not (theme VII). While this idea originated by Ellen (speaker 7) was comprehensive covering both agreement and disagreement, Boseda also referenced the previous boy speakers, Jason, Unika and Darweshi (speakers 1-3), indicating alignment with the preceding girls (theme VI) but also with the earlier boys (theme I).

Speaker # And Name	Theme	Transcript
10a. Boseda	I	I agree with <i>Jason, Unika</i> and <i>Darweshi</i> because air doesn't have no color,
10b.	VI	and I agree with Ellen because sometimes, when it's foggy, it's kind of like brown, a little bit brown outside.

When interviewing the students about how they chose speakers, I found some stating the norms that had been explicitly developed in the discourse communities as described in chapter 4.

- Lori: After you give your idea, and if there is more than one hand raised, how do you decide who to pick next?
- Evan: I just pick the people who were raising, which were raising their hands the most first.
- Lori: Who raised their hands first?
- Evan: Yup.

Evan claimed to make a decision based on who was raising a hand first. Rebecca similarly expressed a group norm of choosing a quiet person with a raised hand. She later added a more personal decision to pick someone who was not mean to her.

Lori: How do students get picked to talk?
 Rebecca: When you be quiet and raise your hand.
 Lori: When you're done (speaking), how do you decide who to pick next?
 Rebecca: Sometimes I pick the person who's not being mean to me.

Other students, however, spoke directly of same gender preferences. When discussing people who talk in the science conversations, Darweshi referenced other boys who were his friends. By stating that most of the girls did not talk, he may have seen only boys as the pool of students to choose for speaking. His perception is interesting as this interview took place after conversation G3 in which there were an equal number of girl and boy speakers which was a typical pattern in this classroom. (See Figure 5.12. Conversations G1 and G2, however, had slightly fewer girl speakers than boy speakers.)

Lori: Who doesn't want to talk?
 Darweshi: Most of the girls.
 Lori: I see. Why do you think that is?
 Darweshi: Because maybe they're shy...
 Lori: Now, who, you mentioned that the kids talk. Can you tell me more about, and that some of the girls don't talk, and who does talk?
 Darweshi: Like me, and Boseda and Unika (all boys).

Natalie was very observant of the turn taking patterns and realized that they may have served to make same gender students, particularly girls, more comfortable. She was dissatisfied with the gender pattern, however, and spoke of breaking it herself.

Lori: How do students get picked to talk when you're in the big circle?
 Natalie: Most of the time it's somebody that they like, and if it's a boy, most of the time, they pick on boys. But like Joey likes Jennifer, so if Jennifer was raising her hand, Joey might call on her rather than just a boy. 'Cause most of the times, if it starts out with a girl, it holds onto the girls, until, like for instance, I like Irving. I might call on Irving.
 Lori: Why are you comfortable picking Irving?
 Natalie: I like him for a friend.
 Lori: Sometimes you also pick girls?
 Natalie: Mmhmm.
 Lori: Why would you pick a girl?

Natalie: Well, because I want both people to have a chance, and some girls don't feel like I do, and they just pick on girls. And we only have a few girls in our class. (There were nine girls and 16 boys in the classroom.) They might just keep picking girls and girls and girls. And if I were the last girl to be picked on, I would pick a boy because they haven't had any chances. And I don't know if the girls would be comfortable, but I wouldn't care if they didn't feel comfortable because I want both people to have a chance. It's not like girls should be lucky only and have a chance to talk.

The *gender clustering* may have constrained the discourse in certain ways. While some students stated the community norms of choosing a speaker who had not yet had a turn, students' options of who to call on often seemed limited to students of the same gender unless the teacher intervened. Students' topical cohesion (Tannen, 1994) and collaborative development of scientific content according to gender (Edelsky, 1993) illustrates how social dynamics cannot be separated from content (Wortham, 1995). The students' expression of content may have been limited to connections with responses by students of the same gender.

On the other hand, the *gender clustering* may be viewed as a community building mechanism. Same gender turns may have allowed certain students to feel comfortable and contribute who otherwise might have had difficulty entering the conversation. The students may have felt their content contributions would be valued more highly by the same gender, and they may have felt more comfortable developing a set of ideas together as girls or boys.

In looking at the opinions expressed by the students as they collaboratively developed a floor, it is interesting to note that the floors developed by the girls in both Figures 5.11 and 5.12 expressed both *agreement* and *disagreement* with the original topic statements. The boy clusters, on the other hand, showed only *disagreement* with the original topic claim. The girls' opinions suggest a more relational, connected

pattern of judgment in which they could see both sides of the argument depending on the context. The boys, on the other hand, may have more easily made autonomous, detached decisions that appeared straightforward. These modes of judgment are similar to those described in women's and girls' psychological development reported by Carol Gilligan (1982) and Lyn Mikel Brown and Carol Gilligan (1992). The responses by the students in this study may indicate very early socialization of these gendered patterns of judgment. These results suggest the potential of further study of children's discourse to better characterize their judgments of scientific ideas and understand the features of the gendered spaces they create in collaboratively developed floors.

Knowledge Sources

Students drew on a variety of relevant knowledge sources expressing traditional, canonical knowledge from school texts and trade books, classroom discussions and investigations. They also verbalized alternative and informal scientific knowledge by referencing specific personal experiences, spontaneous thought experiments, information gathered from family members and friends, cultural traditions and stories and vignettes from popular media such as films and television programs. The students' expressed knowledge, consequently, came from both in and out of school sources. The teachers permitted and encouraged the students to draw upon their entire repertoire of knowledge bases that were pertinent to the scientific topic at hand. The vast majority of student contributions and knowledge sources were relevant to the science conversations. Teachers dismissed occasional fictional and unrelated scientific contributions explaining to students the need to focus on the scientific topic under discussion with non-fictional, relevant comments.

The teachers' explicit encouragement of multiple knowledge sources is demonstrated in Mrs. G's elicitation of a response from the first speaker Jason in conversation G3 about the topic statement, "Air has a color". When Jason first responded that he did not know why he disagreed with the statement, Mrs. G specifically asked him what made him think that air did not have a color.

Mrs. G: What makes you think air has no color? What have you seen or done or read? Is it something you've seen yourself or something you've done or read about?

With her questions Mrs. G let Jason know that a personal observation or experience or a textual reference were all appropriate knowledge sources. Jason then replied with a personal observation.

Jason: Yeah, I don't see any color.

This type of questioning by the teachers encouraged students to justify their claims with any pertinent knowledge sources relevant to the conversation.

The categories of knowledge sources referenced in the science conversations originated from the students' comments. Mostly, students acknowledged an explicit source for the information they were contributing. In some cases, the source could be inferred from the context of the comments. In a few cases, no knowledge source could be discerned from the students' comments.

The individual knowledge categories were first collapsed into broad groups to show general trends. These four broad categories were named *self and others*, *school-based*, *text and media* and *none*. The number and percentage (in italics and parentheses) for each broad group is shown below in Table 5.2.

Table 5.2 – Broad Knowledge Sources in Students' Science Conversations

Knowledge Source	Number (and Percentage) of Student Contributions
Self and Others	149 (65)
School-Based	61 (27)
Text and Media	12 (5)
None	7 (3)

In contrast to traditional classrooms where the teacher and text are the major knowledge authorities, the major sources of students' knowledge in the circle conversations originated from themselves or others (65 %). School-based knowledge was utilized in a little over a quarter of the students' responses. All text and media knowledge sources contributed only five percent of the students' knowledge sources, and very few comments (three percent) had no discernable knowledge source.

The individual knowledge sources comprising the broad groupings (Table 5.2) are listed in Table 5.3 along with the number and percentage of student contributions for the following categories: all conversations, convergent and divergent conversations, contributions by gender and life and physical science topics. Table 5.4 lists the number and percentage of student contributions across the year and for individual conversations. Major trends within each of the conversation categories are reported below.

Trends Across All Conversations

The most significant knowledge sources across all of the conversations were *personal experiences* (31 %), *other students* (28 %), *abstract logic* (19 %) and *thought*

experiments (7 %). The remaining categories each constituted only 0.5-3.5 % of the total student responses.

In all of the conversations (except G2 about the time period of dinosaurs), at least a third of the knowledge source contributions were *personal experiences* that students brought to bear upon the topic at hand (Table 5.4). This high percentage indicates that the topics chosen by the teachers were relevant to the students' lives, and the students had many real life experiences which enabled them to contribute and make sense of the science conversations. An example from conversation G1 in which students were discussing the statement, "All plants die in the winter," illustrates the students' use of personal experiences.

Audrey began the conversation with a relevant personal experience that she had had with her mother.

Audrey: I agree because me and my mom left a plant out in the winter to see if it would die, and when spring came, it died.

Many other students followed Audrey by sharing personal experiences they had had with plants in the winter and other seasonal conditions. This sharing of personal experiences was common in both classrooms and throughout the year (Table 5.4).

The second most significant knowledge source in the students' conversations was *other students*. One of the explicit norms of the conversation from the beginning of the year was that, in their speaking turns, students were to first agree or disagree with the topic statement or another student and then give a reason for their agreement or disagreement. This convention provided links between and across the individual student contributions. The high number of *other student* knowledge sources shows that students often chose to agree or disagree with other students rather than with the

original topic statement. Students may have seen ideas as connected to other people and wanted to express this relationship in their statements. In addition, they may have found the claims and reasons of other students compelling and wished to respond directly to them. Students often mentioned the immediately previous speaker but sometimes referenced multiple speakers as illustrated in this example from conversation G3. The students were discussing the topic sentence, "Air has a color," and Boseda was the last student chosen to share his idea.

Boseda: I agree with Jason, Unika and Darweshi because air doesn't have no color, and I agree with Ellen because sometimes, when it's foggy, it's kind of like brown, a little bit brown outside.

In his turn Boseda agreed with three speakers from the beginning of the conversation and a fourth speaker Ellen who had made a contribution midway in the conversation. In all of the conversations, students often referenced the contributions of other students (Table 5.4).

While both *personal experiences* and *other students* were constituents of the broader category, *self and others*, the third most prevalent knowledge source was *abstract logic* from the *school-based* category. Many of the conversation topics dealt with abstract concepts such as the continual shining of the sun and stars (conversation K2) or the presence of water in air (conversation K3). In these conversations students used the *abstract logic* they had learned in school to address these issues which were removed from their direct, concrete experiences. For example, Yue addressed the topic statement, "There is water in air," in the beginning of conversation K3.

Yue: I agree with the statement because when water's in the air, it's a gas.

Yue correctly used the abstract term *gas* which she probably learned in school to describe the existence of water in air. Similarly, students used abstract logic to a significant degree in the conversations which dealt with concepts apart from concrete objects (Table 5.4).

The last major knowledge source, *thought experiments*, was also a component of the *school-based* category. Students would sometimes spontaneously consider a theoretical scenario which would support their claims about the topic statement. Midway in conversation K1 about the topic statement, "Sight is more important than hearing," Jill shared hypothetical examples of trying to drive without sight and trying to walk on train tracks without the ability to hear a train coming.

Jill: I agree, I agree and disagree with the statement. I disagree with the statement because if you were driving, if you were driving, you couldn't see where you were going, and, and you couldn't see, and you wouldn't know where you were going. And if you couldn't hear, if you were walking on the train tracks, and somebody was trying to tell you that a train was coming, you wouldn't know because you would just think that everyone was waving at you.

The first speaker had begun the conversation with a thought experiment, and many students followed his example. Thought experiments were also shared by a few students in conversation G1 about the topic statement, "All plants die in the winter." Because it was not utilized across many conversations, this knowledge source appeared to be specific to particular topics (Table 5.4).

One interesting finding about the major knowledge sources was their relationship with one another. As previously stated, two of the major knowledge

sources were from the *self and others* category, while the other two major knowledge sources were from the *school-based* category. Often the knowledge source, *personal experiences*, from the *self and others* category worked in concert with a *school-based* knowledge source.

For example, in conversation K1 about the topic statement, "Sight is more important than hearing," most of the students combined a formal *thought experiment* with a potential *personal experience*. The combinations of the two knowledge sources allowed them to comprehend a situation which they had not experienced. In the previous example of a *thought experiment*, Jill created a scenario in which both sight and hearing were important. While she used potential personal experiences which each had some basis in reality, the bringing together of the two experiences within a formal thought experiment allowed her to explore the topic in a thorough and realistic manner.

Similarly, in conversation K3 about the topic statement, "There is water in air," many students combined personal experiences with the school-based knowledge source, *abstract logic*. As discussed in the convergence section, students' initial use of abstract terminology limited the depth and understanding of the topic. However, when students began to combine personal experiences with abstract logic, they were able to deepen their understanding of the topic.

For example, Lucas linked a personal observation he had had of seeing steam come out of factories with the abstract concept of how clouds form and produce rain.

Lucas: Um, I think because when the steam's coming out of factories, it goes into the clouds, and there's water in the steam, so when the cloud gets too heavy, it falls.

Lucas was able to postulate a potential mechanism for the abstract concept of how clouds form and produce rain with a logical explanation using a tangible water source, steam from factories, that he had personally observed. This use of combined personal and school-based knowledge sources was so effective that many students applied the same pattern in the conversations.

Minor knowledge sources included *parents, brother, and cultural references* in the *self and other* category, *proposed experiments* in the *school-based* category, all of the *text and media* knowledge sources and *none*. Brief descriptions and examples of the minor knowledge sources are given below.

In the *self and others* category, students rarely referenced family members as a knowledge source. Outside of teachers in formal settings, one might expect students to commonly reference parents as authoritative knowledge sources. However, only on a few occasions did students reference *parents* or a *brother*. For example, Sook-Joo mentioned her brother as her knowledge source in conversation K2 about the topic statement, “The sun is always shining.”

Sook-Joo: I agree with the statement because I learned from my brother that the sun is always shining because it’s on the other sight of the earth, and at night, the moon is just covering the sun so it looks like (inaudible)... The moon is just in the sun’s way.

A few references to a *parent* or *brother* were also made in conversations G1 and K3 (Table 5.4).

The other minor knowledge source in the *self and others* category was *cultural references*. This knowledge source seemed to be specific to particular conversations, especially G1 in which students were discussing the topic statement, “All plants die in

the winter.” As some of the students were unfamiliar with Midwestern winters, they asked if they might speak about the seasonal effects of weather on plants in their own countries.

Manuel: I disagree because in Mexico, no plants die in the winter.

Mrs. G: What’s winter like in Mexico?

Manuel: It doesn’t snow. You don’t have to wear snow boots. You can wear tennis shoes.

Mrs. G: But all the plants live? Do they change at all?

Manuel: Well, at least their flowers fall off, but they’re still alive.

Manuel was the first speaker who talked about plants in other countries. Once Mrs. G assured the validity of these contributions, other students shared the effects of winter or other seasons on plants in their countries. Single *cultural references* were also made in conversations K2 and K3.

In the *school-based* category, only one *proposed experiment* was suggested, and this occurred in conversation G1. Hearing about various students’ experiences trying to grow plants in the winter, Unika thought of an actual experiment he might try using his school-based knowledge of checking the differing claims he had heard.

Unika: I kind of agree, and I kind of disagree. I kind of agree and disagree ‘cause when it’s winter, I’m going to check if the plants really grow, or if they really die ‘cause I don’t really know if they will grow.

Few knowledge sources in the *text and media* category including *books, stories, religion, video* and *games* were referenced. In one conversation G2 (Table 5.4), all of these knowledge sources together played a significant role as students debated the validity of various knowledge sources. Audrey began the conversation about the topic

questions, “When did dinosaurs live? Did they live on earth all at the same time?” by referencing a game she had played.

Audrey: I disagree because at home, I have something about dinosaurs, and they have three different time periods.

Mrs. G: Three different what?

Audrey: Three different time periods when the dinosaurs lived.

Mrs. G: Do you want to explain more about that, or do you remember?

Audrey: There’s a game. You have to try and say 15 dinosaurs from all three different time periods.

Throughout the conversation, other students referenced books, stories, religion and videos.

Unika: I agree with He-Ping because I saw this video from a long time ago, um, these, I saw this guy, and he looked just like a monkey...

Ellen: I disagree with Unika because... When all the dinosaurs extinct, the first people on earth were Adam and Eve.

Ellen’s disagreement with Unika signals the beginning questioning of knowledge sources as a way of justifying or discarding differing claims and reasons. This questioning became heated as the conversation proceeded with many opposing, controversial claims and reasons shared.

He-Ping: I agree with Darweshi and Unika and disagree with Nimah and Alisha because how can cave men, I know that the real truth is that people and dinosaurs did not live at the same time.

Nimah: There weren’t people. They were cave men.

He-Ping: Cave men were not even.

Alisha: Cave men are not people!

He-Ping: Cave men were not even lived at the same time. It was the one who, no one, you guys (to Nimah and Alisha) just watch fantasy movies because

how can cave people be at the same time as dinosaurs? And Darweshi was the, and Unika was the only ones who were correct...

Mila: I think that I agree and disagree that I'm not really sure that cave people started the stories that it's about dinosaurs that have cave people on it. I think it's fake, and that's because dinosaurs, I know that humans or people, not even one person lived when dinosaurs lived.

At the end of the conversation, Juwan tried to strengthen his previous knowledge source of a book by emphasizing that it had the word *real* in the title.

Juwan: I disagree with her (Mila) and He-Ping because for one thing, talking about dinosaur movies, for one thing, I read a book that it said, the name of the book was Real Stories about Dinosaurs and People. Cave men looked like monkeys, but mon, but they were not monkeys. No.

However, the last speaker Boseda challenged even this nonfiction book.

Boseda: I just want to tell Juwan that I agree, I mean I disagree because some books are not, not (pause)

Mrs. G: Accurate? (Boseda nods yes.) Juwan, we were finding out earlier that not even all books even agree, that different authors have different opinions. That's what he's sharing because you weren't here when we found that out, but go on (to Boseda).

Boseda: Some books are.

Mrs. G's comments illustrate how the teachers encouraged and expected a variety of relevant knowledge sources to support the students' claims. Standard knowledge sources of the teacher or school science text were not used in the conversations and may have been considered insufficient to fully justify the claims and reasons given.

Rarely did students indicate *no* knowledge source for their contributions. Usually, this occurred when students simply agreed or disagreed with a topic statement and provided no reason for their claim. For example, in conversation K3 about the topic statement, “There is water in air,” Kyubok agreed without a reason or knowledge source.

Kyubok: I agree with the statement.

Though the lack of knowledge sources occurred in most conversations, the number of contributions was always small (Table 5.4).

Trends in Convergent and Divergent Conversations

While both convergent and divergent conversations had similar major knowledge sources, the prevalence of the knowledge sources was different in each conversation type. The major knowledge sources in convergent conversations were *personal experiences* (37 %), *abstract logic* (27 %), *other students* (16.5 %) and *thought experiments* (11 %), while the order of major knowledge sources in divergent conversations were *other students* (41.5 %), *personal experiences* (23 %), *abstract logic* (8.5 %) and *cultural references* (6 %).

The high number of *personal experiences* and *abstract logic* knowledge sources in convergent conversations may indicate the powerful and compelling combination of these two knowledge sources for students. Personal experiences may have provided a comfortable space and connection for students to agree with one another. The addition of abstract logic may have provided a convincing argument in which to locate the concrete experiences. Students may have found the combination of personal experience and abstract logic knowledge sources used by the initial speakers compelling and decided to follow this pattern in their own turns.

Referencing *other students* was also a major knowledge source in convergent conversations but to a lesser degree than in divergent conversations. Students in convergent conversations often referenced only the immediately previous speaker. Since they were in agreement about the topic claim, students may not have felt it necessary to mention multiple previous speakers as was done in the divergent conversations.

The prevalence of *thought experiments* in convergent conversations was due to the high number of thought experiment knowledge sources in conversation K1 (Table 5.4). Thought experiments seemed to be a school-based knowledge source that was integral to particular topics (conversation G1 about plants in winter and conversation K1 about sight and hearing) and may not have been a key knowledge source in general for convergent conversations. However, their usefulness in particular conversations, as well as in the field of science itself suggests that they are worth exploring more fully in school contexts (Gilbert & Reiner, 2000; Sorensen, 1992).

For divergent conversations *other students* represented nearly half of the knowledge sources. While the category of other students was a predominant knowledge source in convergent conversations, it was not utilized to as great an extent as it was in divergent conversations. Often, students would represent multiple previous speakers in divergent conversations. These references might include statements of agreement and disagreement. The predominance of this knowledge source in divergent conversations shows how well students kept track of the diverse opinions expressed in the conversations and their need to specifically reference the previous speakers as they introduced, developed or negated lines of reasoning.

As in the convergent conversations, *personal experiences* and *abstract logic* were also significant knowledge sources in the divergent conversations, and the combination of these knowledge sources was present in both conversation types. As with *thought experiments* in convergent conversations, the fourth largest knowledge source in divergent conversations, *cultural references*, was a feature of particular conversations (G1 in Table 5.4) rather than of divergent conversations, in general.

Trends Between Girls and Boys

There were a few differences between boys' and girls' knowledge sources. The major knowledge source for girls was *personal experiences* (30 %), while *other students* (33 %) was the major knowledge source for boys followed closely by *personal experiences* (30 %). Likewise, *other students* (21 %) was the second major knowledge source for girls. The third and fourth major knowledge sources were *abstract logic* and *thought experiments* for both boys and girls. Use of the minor knowledge sources was similar between the genders with the exception of family references (*parents* and *brother*) and stories noted only by girls.

Although both boys and girls used *personal experience* knowledge sources to a similar degree, boys referenced *other students* (33 %) to a greater degree than did girls (21 %). It is not completely clear why this pattern occurred, but a closer look at the trend of agreement and disagreement by gender when referencing other students may clarify boys' greater use of this knowledge source as well as further elaborate the pattern of *gender clusters* described previously. The following table displays the number and prevalence of agreement and disagreement with girls and boys made by speakers when referencing other students (Table 5.5). The number of knowledge

sources is followed by the corresponding percentage (in italics and parentheses) for each category.

Table 5.5 – Nature of Gender References of *Other Students* Knowledge Source

Gender Of Speaker	Agree with Girls	Agree with Boys	Disagree with Girls	Disagree With Boys	Reference without Agreement or Disagreement
Girls	11 (55)	2 (10)	1 (5)	5 (25)	1 (5)
Boys	10 (23)	20 (45.5)	5 (11)	9 (20.5)	0 (0)

In corroboration of the *gender cluster* analyses, Table 5.5 shows that both girls and boys were most likely to agree with a student of the same gender when referencing other students. However, the pattern was more pronounced with girls than boys. This trend supports the finding of students collaboratively developing the floor in same *gender clusters* in both convergent and divergent conversations. In a gender cluster sequence, students would often argue with previous same gender speakers and then further develop and elaborate the reasoning to support the agreed upon claim.

Disagreements with other speakers were much less frequent than agreements. In a similar pattern to that seen for agreements, girls were much more likely to disagree with boys than with girls. Boys, on the other hand, more frequently disagreed with boys than with girls. As with agreements the pattern for girls was more distinct than the pattern for boys.

Clearly, both genders felt most comfortable agreeing with same gender speakers leading to the pattern of *gender clusters* and collaborative development of knowledge. However, the opposing patterns of disagreement for boys and girls may

indicate different tendencies for the genders. Girls appear much more firmly aligned by gender with strong patterns of agreement with girls and disagreement with boys. Boys, conversely, seem to be much more comfortable agreeing and especially disagreeing with either gender. This may explain why they were more likely to reference other speakers than were girls. Perhaps boys more easily mentioned other speakers regardless of whether or not their comments were in agreement or disagreement. Girls may have been more likely to reference other students if it meant agreeing with another girl or disagreeing with a boy.

As for the other knowledge sources, both genders seemed equally comfortable using the school-based knowledge sources of *abstract logic* and *thought experiments*. However, girls only used the less traditional knowledge sources of family members and stories, but only to a small degree.

Trends in Life and Physical Sciences

The major knowledge source in life science was *other students* (32 %), while *personal experiences* (36 %) were the major knowledge source in physical science. *Personal experiences* (26 %) were the second major knowledge source in life science, while, perhaps expectedly, *abstract logic* (30.5 %) was the second major knowledge source in physical science. The third major knowledge source for life science was *thought experiments* (15 %) which were not referenced at all in physical science. The third major knowledge source in physical science was *other students* (24 %). To a lesser degree than in physical science, *abstract logic* (6 %) was the fourth major knowledge source for life science. Other knowledge sources in physical science were each less than 3 %.

Trends over Time

The use of most knowledge sources by students was fairly consistent across time as shown in Table 5.4. Students regularly used the self and other knowledge sources of *personal experiences* and *other students* to a great extent over time. Their use of the school-based knowledge source of *abstract logic* was not used in the beginning of the year but consistently after that, and *thought experiments* were used only in the beginning of the year. *Text and media* sources were used significantly in only one middle of the year conversation (G2). The use of *no* knowledge source stayed at a low level from the beginning to the end of the year. As previously mentioned, the specific topic or mode of response by initial speakers may have also had a significant impact on the knowledge sources used by students.

The varied formal and informal knowledge bases used by these students appear to be broader than canonical scientific knowledge and gave greater access and richness to their conversations. The strong emphasis on students' personal experiences as a knowledge source suggests that the students saw their ideas and activities as important and relevant to scientific understanding. Similarly, the nearly equal importance of other students' opinions as a knowledge source implies a norm that *all* members' opinions in a scientific community are to be listened to and valued with respectful agreement or disagreement. The low frequency of authoritative knowledge sources such as the teachers or school texts indicates that the students viewed the locus of authority for these conversations within their own community.

Summary

As students co-constructed and built knowledge in the conversations, they sometimes followed convergent (similar knowledge) and, at other times, divergent

(differing knowledge) paths. Students showed convergence of a scientific idea when a number of contributions were in agreement. Often, students would explicitly state their support of a previous student's comment and give additional evidence or similar experiences of their own as reasons for their support.

Conversely, students shared many divergent ways of thinking by some agreeing and others disagreeing with the science statement, some agreeing and disagreeing within a single turn and some occasionally changing their opinions in subsequent turns. In divergent discussions, many students noted the inadequacy of the statement to represent their full experiences and further elaborated the scientific topic. Toward the end of many of the conversations, students were taking on fuller, more thoughtful and sophisticated positions. In both convergent and divergent conversations, gender contributed a significant role as students collaboratively constructed knowledge along gender lines. Students also drew on a variety of formal and informal knowledge sources throughout the conversations.

Characteristics of Convergent Conversations

In brief, convergent conversations were characterized by similar topic claims with divergent but complementary reasons. The similar topic claims provided a point of consensus around which the students could explore and develop their reasoning. For example, as students discussed the topic statements, "The sun is always shining," and "The stars are always shining" in conversation K2, they all agreed with the initial statements. Their reasons for agreement were sometimes similar but often different (Figure 5.4). The differing reasons were complementary, however, and provided a rich array of knowledge around the common topic claim core.

In convergent conversations the array of knowledge constructed by the students'

reasons sometimes developed depth of the topic by progressing through increasingly complex concepts (Woodruff & Brett, 1999). This pattern was illustrated in conversation K3 with the topic claim, "There is water in air." The conversation began with a surface level discussion of abstract terminology. Sensing the limits of the conversation, the teacher pushed for more explicit explanations. The students responded by locating the abstract terminology in partial explanations of the water cycle. The students also began sharing specific, concrete examples of water in air from their life experiences. As the conversation progressed, the students provided links between the water cycle and abstract terms and between real life examples and abstract terms. Thus, the conversation proceeded from a surface recitation of abstract terms to a more complete explanation of the water cycle with appropriate scientific terminology situated within specific contexts.

Characteristics of Divergent Conversations

Both divergent claims and reasons characterized divergent conversations. Students broadened the breadth and complexity of the original topic in divergent conversations and occasionally pursued productive side trips by exploring issues of interest that were related to the topic claim. For example, students discussed multiple reasons of agreement and disagreement with the topic statement, "All plants die in the winter," in a beginning of the year conversation (G1) in Mrs. G's class. The conversation never reached a consensus. Instead, the students explored a variety of issues (all vs. some plants, weather, water, location, investigations and new plants) that need to be considered in determining whether or not plants live or die in winter and other seasonal conditions. Mrs. G's encouragement of students' diverse opinions permitted many students to contribute to the conversation enhancing its breadth and richness in the process.

A pattern of increased breadth through productive side trips was also observed in the divergent conversations. For example, students explored the topic questions, “When did dinosaurs live?” and “Did they all live at the same time?” in a middle of the year conversation (G2) in Mrs. G’s class. Early in the conversation, students pursued a persistent side trip focusing on human existence and form at the time of dinosaurs. This related issue was of great interest to students, and their development of the human topic allowed students to express and explore multiple, differing points of view. The conversation provided them with a venue to place the original topic of time periods of dinosaurs into a larger framework of history and relations of humans with dinosaurs.

Gendered Construction of Knowledge across Conversations

In both convergent and divergent conversations there was a pattern of gendered construction of knowledge. This pattern was illustrated in a beginning of the year convergent conversation (K1) in Mr. K’s class and an end of the year divergent conversation (G3) in Mrs. G’s class. Students often called on same gender speakers who would frequently agree with and reference prior speakers producing gender alignment and topical cohesion (Scanlon, 2000; Tannen, 1994). Within these *gender clusters*, speakers would typically elaborate on the reasoning of the previous speaker resulting in collaborative development of the floor (Edelsky, 1993). The gender clusters may have limited the conversations if students saw their own gender only as potential speakers. However, the gender clusters may also have served as a community building mechanism allowing students to explore and develop controversial topics safely with students with whom they felt the most comfortable.

Knowledge Sources in Conversations

Students used a variety of formal and informal knowledge sources to substantiate their contributions to the science conversations. Students mostly drew on knowledge sources from themselves and others. Within this broad category, the most predominant individual knowledge sources were *personal experiences* and references to *other students*. School-based knowledge also contributed significantly to the students' contributions. In particular, students often used *abstract logic* and sometimes *thought experiments* to explain their claims and reasons. Interactions often occurred between the *self and others* and *school-based* knowledge sources demonstrating fruitful combinations of formal and informal knowledge. Students rarely used *text and media* or gave *no* knowledge source for their statements.

There were a few patterns of knowledge sources across conversation types. Students used both *personal experiences* and *abstract logic* together to exemplify general scientific principles with concrete instances in convergent conversations. This combination of knowledge sources provided a compelling pattern followed by many students as they reached consensus about a topic. For divergent conversations, references to *other students* were important as students referenced specific previous speakers in keeping track and developing numerous lines of argument.

Both girls and boys equally referenced *personal experiences* as knowledge sources, but boys were more likely to mention *other students* than were girls. In referencing other students, both genders mainly agreed with same gender speakers. However, when disagreeing, both genders were more likely to disagree with boys.

The major knowledge source in life science was *other students*, while *personal experiences* were the major knowledge source in physical science. Students' use of

knowledge sources was fairly consistent over time, but some knowledge sources such as *text and media* were restricted to specific topics.

Discussion

The expected course of a scientific discussion from some traditional and conceptual change research is that students will begin with many divergent opinions and conclude with a common, canonical understanding (e.g., Bishop & Anderson, 1990; Posner, Strike, Hewson & Gertzog, 1982; Smith, 1990). More recently, other researchers (e.g., Barnes, Britton and Torbe, 1990; Denyer, 1993; Warren, Conant, Ogonowski & Puttick, 1998) have begun to explore the value of divergent paths of knowledge construction. The development of knowledge in these conversations followed both convergent and divergent paths. Sometimes, students followed the expected path of reaching a consensus at the end of the conversation. Nonetheless, the teachers did not restrict the students to this one pattern, and they engaged in productive scientific conversations along convergent as well as divergent paths.

Student ownership with a few reminders of relevance by teachers afforded multiple, varying convergent and divergent paths for the science conversations. Most student contributions were relevant to the conversations, and each conversation was a productive forum for discussion of the scientific topic. In this analysis, different but advantageous outcomes were identified for the convergent and divergent paths. Convergent conversations produced a sense of common understanding in the community. At other times, initially simple ideas were pushed to deeper understandings. Divergent conversations often raised interesting, open-ended questions about the scientific topic. Sometimes, a number of related, complex issues were brought to bear upon the beginning topic in divergent conversations. The pattern

of *gender clustering* within the divergent and convergent conversations may have permitted more students to feel comfortable and included in the conversations and may have furthered the scientific conversations by allowing students to more freely develop ideas cohesively and collaboratively.

Cunningham and Fitzgerald's (1996) description of three areas of knowledge is salient to this work. Like them, I am also interested in looking at what counts as knowledge, where it is located and how it progresses. In the semi-structured format of these conversations, students had a great deal of freedom and were encouraged by their teachers to choose from a large spectrum of knowledge sources. Including knowledge from relevant personal, informal experiences along with more traditional classroom science activities helped students to see that science was a part of their lives both in and out of school (Pomeroy, 1994). Teachers and students valued all relevant, non-fictional science experiences shared. The broad knowledge bases, thus, gave access to the science conversations for most of the students. These conversational experiences were, of course, supplemented with teacher-directed class discussions, small group science investigations and individual journal writing. Together, these science activities gave students multiple and varied experiences with science.

Expanding the Discourse through Knowledge Construction in Circle Conversations

These classroom communities provided opportunities for *expansion* of the discourse (Weiler, 1988) that are often missed in traditional lecture or initiation-response-evaluation (Cazden, 1988) forms of discourse. Convergent conversations and same gender convergent clusters provided a core of common knowledge around which students could explore and develop divergent reasons in a safe context. This pattern

was illustrated in conversation K1 in which students discussed the topic statement, “Sight is more important than hearing”. Most of the students came to the conclusion that sight and hearing were equally important and then elaborated their reasoning within same gender clusters.

Divergent conversations *expanded* the discourse by allowing an open forum in which students could pursue an array of related, key issues relevant to the topic under question. Like authentic discourse in scientific research, divergent conversations often raised a number of valid issues for which there were not simple, clear cut answers. This was exemplified in conversation G1 about the topic statement, “All plants die in the winter”. The students brought up a number of important issues about plant growth in winter and other seasonal conditions experienced by the students in tropical climates.

By permitting a multitude of informal and formal knowledge sources, the students *expanded* the conversations by exploring both concrete instances (personal experiences) and abstract concepts (school-based knowledge). In addition, they valued and utilized the contributions of other class members. The intersection of their knowledge sources afforded within these conversations seemed particularly fruitful as demonstrated in conversation G3 in which students were discussing the topic statement, “Air has a color”. Students combined their personal experiences of looking at air with abstract, school-based concepts such as *invisible* often referencing more than one previous speaker.

Constraining the Discourse through Knowledge Construction in Circle Conversations

On the other hand, the conversations may have been *constrained* in some ways. Convergent conversations were at risk of being short and superficial. This was demonstrated in K2 when the students quickly reached consensus about the topic statement, “The sun is always shining.” The swift consensus precluded a full discussion of students’ reasons for their claims. Mr. K responded by introducing a second, related topic, “The stars are always shining,” in which students could work further with similar ideas. Convergent *gender clusters* may have limited students to viewing only members of the same gender as their discourse community rather than the entire class.

Likewise, divergent conversations ran the risk of becoming a loose, disconnected set of isolated ideas. There was also the chance of students becoming sidetracked to the point of evading the original topic all together. For example, Mrs. G responded to students’ pursuit of the side topic, human form at the time of dinosaurs, in conversation G2 by repeatedly asking students to relate their comments about humans to dinosaurs.

Limiting or favoring one or a few knowledge sources also *constrained* the discourse at times. This was apparent in the beginning of conversation K3 when students first tried to discuss the topic statement, “There is water in air,” using only abstract terminology. Fortunately, with the teacher’s encouragement some students later brought in personal experiences which provided real contexts in which the abstract concepts could be applied.

Authentic Science Discourse Through Alternative and Traditional Means of Expressing Knowledge, Language and Subjectivities

Like the multiple knowledge forms and sources expressed in the analyzed conversations, the use of convergent and divergent paths allowed for productive and authentic scientific discourse. The fruitfulness of these diverse conversations invites more exploration of both convergence and divergence as well as formal and informal knowledge sources in students' scientific discussions.

Broadly, this chapter introduces an overriding theme which is pertinent to the other two analysis chapters that look at language and subjectivities in elementary science discourse. The teachers and students in the elementary science classrooms in this study illustrate valid and fruitful ways to engage and understand science beyond the traditional forms which most of us have learned. In this chapter, divergent patterns of knowledge progression were shown to have differing yet worthwhile qualities which complement traditional convergent knowledge development in typical science classrooms. The importance of the subjective feature, gender, an integral facet of knowledge development and students' entire school experiences, was demonstrated here as well and will continue to be studied in the remaining chapters. The use of informal knowledge sources such as personal experiences was shown to greatly enhance the variety of ideas in the conversations as well as help to make the abstract, school-based knowledge understandable.

In a similar vein, the next chapter will consider the value of children's use of narrative along with traditional paradigmatic language features as they talk about science in the circle conversations. Finally, the last analysis chapter will look at the place of subjectivities, students' personal and social characteristics and observations, in

students' science journal writing. Like divergent knowledge and narrative language, subjectivities have traditionally been overlooked in children's school science experiences. I will attempt to show how including and valuing these alternatives as complements to traditional science instruction can enrich elementary science discourse.

Table 5.1 - Overview of Convergence/Divergence in Students' Science Conversations

Class Code	Time of Year	Topic Sentence	Science Topic	Claim Outcome	Reasons Outcome	Total # of Student Turns
G1	Beginning	All plants die in the winter. When did dinosaurs live?	Life	Divergent	Divergent	20
G2	Middle	Did they all live at the same time?	Life	Divergent	Divergent	20
G3	End	Air has a color.	Physical	Divergent	Divergent	10
K1	Beginning	Sight is more important than hearing. The sun is always shining.	Life	Convergent	Divergent	16
K2	Middle	The stars are always shining.	Physical	Convergent	Divergent	9
K3	End	There is water in air.	Physical	Convergent	Divergent	25

Abbreviations:

G: Mrs. G's Class

K: Mr. K's Class

Table 5.3 – Trends in Knowledge Sources across Students' Science Conversations

Con-versa-tion Code	KNOWLEDGE SOURCES													
	Self and Others				School-Based				Text and Media				None	
	Personal Ex-peri-ences	Parents	Brother	Other Stu-dents	Cul-tural Refs.	Ab-stract Logic	Thought Expt.	Pro-posed Expt.	Books	Stories	Reli-gion	Video		Games
All	71 ^a (31) ^b	3 (1.5)	3 (1.5)	64 (28)	8 (3.5)	43 (19)	17 (7)	1 (0.5)	4 (2)	3 (1.5)	3 (1.5)	1 (0.5)	1 (0.5)	7 (3)
Con-ver-gent	47 (37)	1 (1)	2 (1.5)	21 (16.5)	2 (1.5)	34 (27)	14 (11)		1 (1)	1 (1)	1 (1)			2 (1.5)
Di-ver-gent	24 (23)	2 (2)	1 (1)	43 (41.5)	6 (6)	9 (8.5)	3 (3)	1 (1)	3 (3)	2 (2)	2 (2)	1 (1)	1 (1)	5 (5)
Girls	29 (30)	3 (3)	3 (3)	20 (21)	5 (5)	19 (20)	8 (8)		1 (1)	3 (3)	2 (2)		1 (1)	3 (3)
Boys	42 (32)			44 (33)	3 (2)	24 (18)	9 (7)	1 (1)	3 (2)		1 (1)	1 (1)		4 (3)
Life	29 (26)	2 (2)	1 (1)	36 (32)	6 (5)	7 (6)	17 (15)	1 (1)	3 (2.5)	2 (2)	2 (2)	1 (1)	1 (1)	4 (3.5)
Phys-ical	42 (36)	1 (1)	2 (1.5)	28 (24)	2 (1.5)	36 (30.5)			1 (1)	1 (1)	1 (1)			3 (2.5)

Codes:

^a Number of student contributions^b Percentage of student contributions (in parentheses and italics)

No contributions

Table 5.4 – Trends across Time and Specific Knowledge Sources in Individual Science Conversations

Con- versa- tion Code	KNOWLEDGE SOURCES													
	Self and Others				School-Based				Text and Media					
	Personal Experi- ences	Parents	Brother	Other Stu- dents	Cul- tural Refs.	Ab- stract Logic	Thought Expt.	Pro- posed Expt.	Books	Stories	Reli- gion	Video	Games	None
Beg- Year	29 ^a (39) ^b	2 (3)	1 (1)	18 (24)	6 (8)		17 (23)	1 (1)						1 (1)
Mid- Year	17 (21)		1 (1)	25 (31)	1 (1)	23 (28)			3 (4)	3 (4)	2 (3)	1 (1)	1 (1)	4 (5)
End Year	25 (34)	1 (1.4)	1 (1.4)	21 (29)	1 (1.4)	20 (27)			1 (1.4)	2 (2)	1 (1.4)			2 (3)
G1	15 (38)	2 (5)	1 (3)	10 (26)	6 (15)		3 (7)	1 (3)						1 (3)
G2				18 (49)		7 (19)			3 (8)	2 (5)	2 (5)	1 (3)	1 (3)	3 (8)
G3	9 (33)			15 (56)		2 (7)								1 (4)
K1	14 (39)			8 (22)			14 (39)							
K2	17 (39)		1 (2)	7 (16)	1 (2)	16 (36)				1 (2)				1 (2)
K3	16 (35)	1 (2)	1 (2)	6 (13.5)	1 (2)	18 (39.5)			1 (2)		1 (2)			1 (2)

Codes:

^a	Number of student contributions
^b	Percentage of student contributions (in parentheses and italics)
	No contributions

AGREE

Time 9:07

4 7 8 15b 17a 9:27

IV. NO PLANTS DIE IN WINTER IN SOME COUNTRIES.

6 27 8

VI. SNOW PROTECTS PLANTS FROM DYING.

15c

X. PLANTS WITHOUT WATER OR TOO MUCH WATER DIE.

14b

IX. NEW PLANTS MAY GROW FROM DEAD PLANTS.

11b 15a 16a

VIII. SOME PLANTS DIE IN WINTER.

9b 10a

VII. WIND BLOWS SOME PLANTS DOWN IN FALL, AND THEY DIE.

5 9a 10b 12 13 14a 18a

V. HARD SNOW MAKES PLANTS FALL AND DIE.

3b

III. CAN GROW NEW PLANTS WHEN PLANTS DIE.

2a 19a

II. ALL PLANTS DIE IN THE WINTER.

1 3a 11a

I. PLANTS OUTSIDE DIE.

DISAGREE

16b

XII. PLANTS INSIDE DO NOT DIE IN WINTER.

18b

XIII. SOME PLANTS DO NOT DIE IN WINTER.

16c

XIV. INVESTIGATE WHETHER PLANTS LIVE OR DIE IN WINTER.

17c

XV. SOME PLANTS DO NOT DIE IN WINTER IN SOME COUNTRIES.

Speaker's Comments

Figure 5.2 - Abbreviated G1 Timeline: Divergent Claims and Reasons

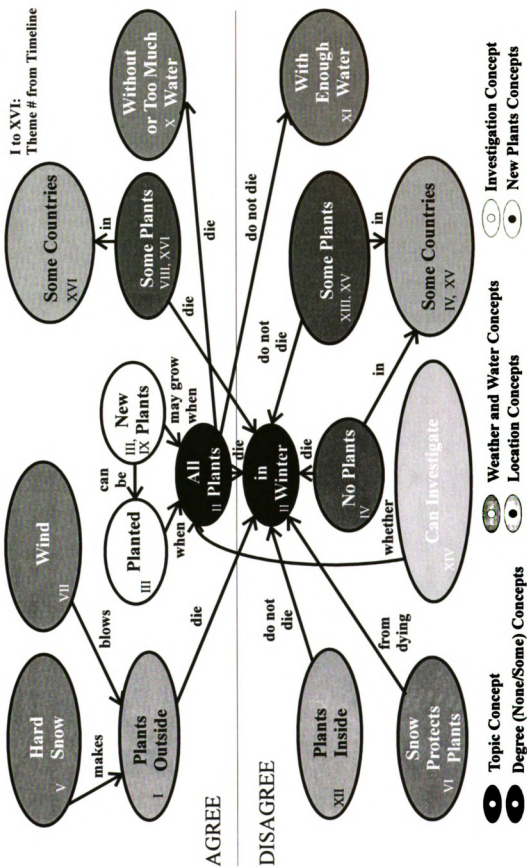


Figure 5.3 - G1 Concept Map: Divergent Claims and Reasons

Topic Statement: The sun is always shining.

AGREE

- 9b VII. DAY AND NIGHT CAUSED BY EARTH'S ROTATION.
- 5b 8a VI. WHEN DAY HERE, IT IS NIGHT ON OTHER SIDE OF EARTH.
- 4 6b V. MOON IS ON OTHER SIDE OF EARTH DURING THE DAY.
- 3c 5a IV. MOON SHINES BECAUSE OF SUN'S REFLECTED LIGHT.
- 3a III. SUN MOVES UP AND DOWN OVER THE COURSE OF A DAY.
- 2b II. MOON COVERS THE SUN AT NIGHT.

2a 3b 6a 7 8b 9a
I. SUN IS ON OTHER SIDE OF EARTH AT NIGHT.

Time 11:12 11:20

Topic Statement: The stars are always shining.

AGREE

- 16b 18 IX. CAN SEE STARS BETTER AT NIGHT BECAUSE SUN IS NOT SHINING.
- 16a 18 VIII. CAN SEE STARS WHEN SUN IS SHINING.
- 15b 18 VII. CANNOT SEE STARS DURING THE DAY BECAUSE CLOUDS COVER THEM.
- 13b 18 VI. AT NIGHT, SUN AND MOON MOVE, BUT STARS STAY IN ONE PLACE.
- 12b 18 V. STARS SHINE ON OTHER SIDE OF EARTH WHEN SUN IS NOT THERE.
- 12a 13a 18 IV. SUN GETS IN STARS' WAY AND THEY CANNOT SHINE.
- 11 18 III. SUN SCARES STARS AWAY TO OTHER SIDE OF EARTH.

14 17b 18 II. CAN SEE STARS AT NIGHT BECAUSE IT IS DARK AND MOON IS LESS BRIGHT THAN SUN.

10a 14 15a 17a 18
I. CANNOT SEE STARS DURING THE DAY BECAUSE SUN IS TOO BRIGHT.

Time 11:20 11:27

Speaker's Comments

Figure 5.4 - K2 Timeline: Convergent Claims and Divergent Reasons

Topic Statement: The sun is always shining.

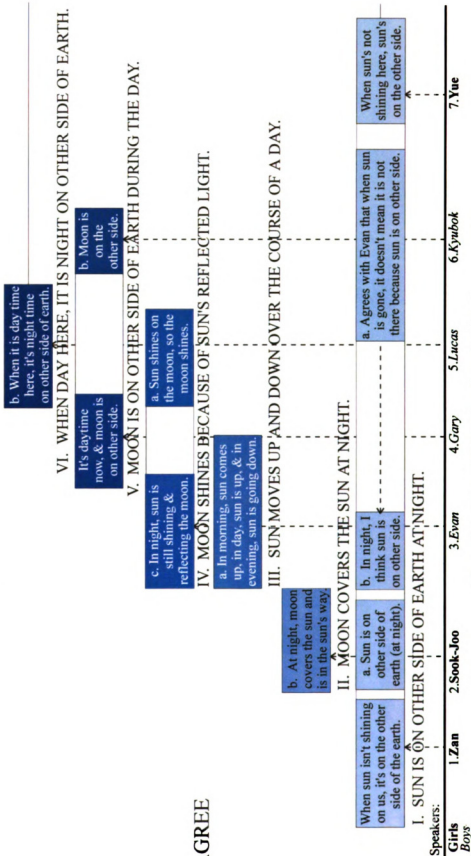


Figure 5.5 - Extended K2 Timeline: Section 1

Topic Statement: There is water in the air.

XV. IF COOKING WITHOUT WATER, THERE IS NO STEAM.

XIV. STEAM IS WATER.

XIII. THERE IS WATER IN THE AIR.

XII. SOMETIMES GET WATER IN BODY BY BREATHING IT IN AIR.

XI. CANNOT FEEL WATER IN AIR.

X. FULL RAIN CLOUDS ARE LIKE FULL BLADDERS.

IX. YOU CAN'T FEEL WATER IN AIR LIKE YOU CAN'T FEEL JESUS.

AGREE

VIII. WATER GOES THROUGH CHANGES AS IT CYCLES FROM GROUND TO AIR TO CLOUDS.

VII. CAN FEEL WETNESS FROM INVISIBLE WATER OR STEAM IN AIR.

VI. WATER EVAPORATES AND GOES TO WIND AND CLOUDS.

V. WATER IN AIR IS A GAS WHICH EVAPORATED.

IV. GAS IS LIKE STEAM OR WATER VAPOR.

III. WATER IN AIR IS A GAS.

II. WATER IS SOMETIMES INVISIBLE.

I. WATER IN AIR IS INVISIBLE.

Speaker's Comments

Time 11:07

Figure 5.6 - K3 Timeline: Increased Depth through Concept Progression

11:24

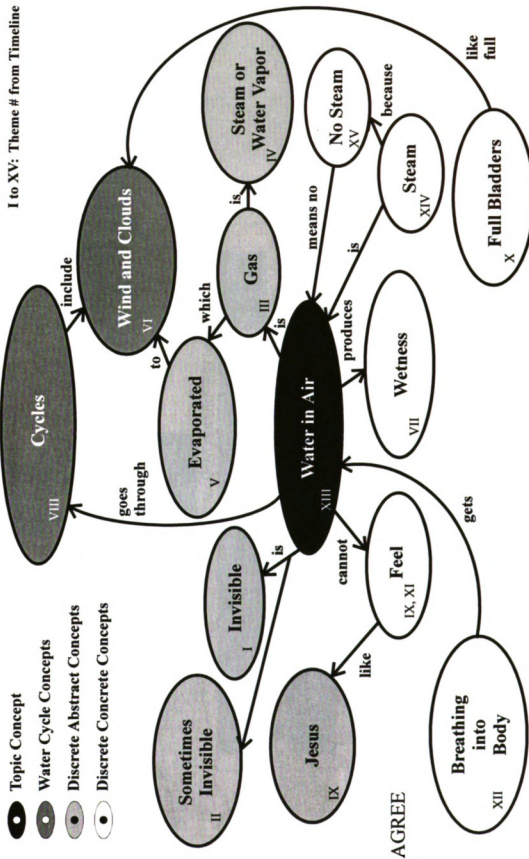


Figure 5.7 - K3 Concept Map: Increased Depth through Concept Progression

Topic Statement: When did dinosaurs live? Did they live on earth all at the same time?

AGREE

5c. Monkeys grew up to be human.

VII. MONKEYS EVOLVED TO BECOME HUMAN.

5d. Humans were monkeys. 6a. Agrees with He-Ping. Saw a video & a guy looked like a monkey. 7. There weren't monkeys. There were cave men, cave people. 8b. Disagrees with Unika because first people on earth were Adam & Eve.

VI. HUMANS WERE IN DIFFERENT FORMS AT THE TIME OF DINOSAURS.

5b. Dinosaurs extinct down.

8a. When dinosaurs (became) extinct

V. DINOSAURS BECAME EXTINCT.

5c. Agrees with Darweshi. Dinosaurs did not live at the same time as humans. 6b. Dinosaurs lived before people.

III. HUMANS DID NOT LIVE AT THE SAME TIME AS DINOSAURS.

2a. Dinosaurs lived a long time ago. 4a. Dinosaurs lived thousands of years ago. 5a. Disagrees with Juwan. Dinosaurs lived 35 million years ago.

II. DINOSAURS LIVED LONG AGO.

Speakers: 1. Audrey

Girls
Boys

2. Unika 3. Darweshi

4. Juwan 5. He-Ping

6. Unika

7. Nimah

8. Ellen

1. Has a game about dinosaurs & they have 3 different time periods.

4b. Disagrees with Audrey. Book said dinosaurs had 10 time periods.

I. DINOSAURS LIVED IN DIFFERENT TIME PERIODS.

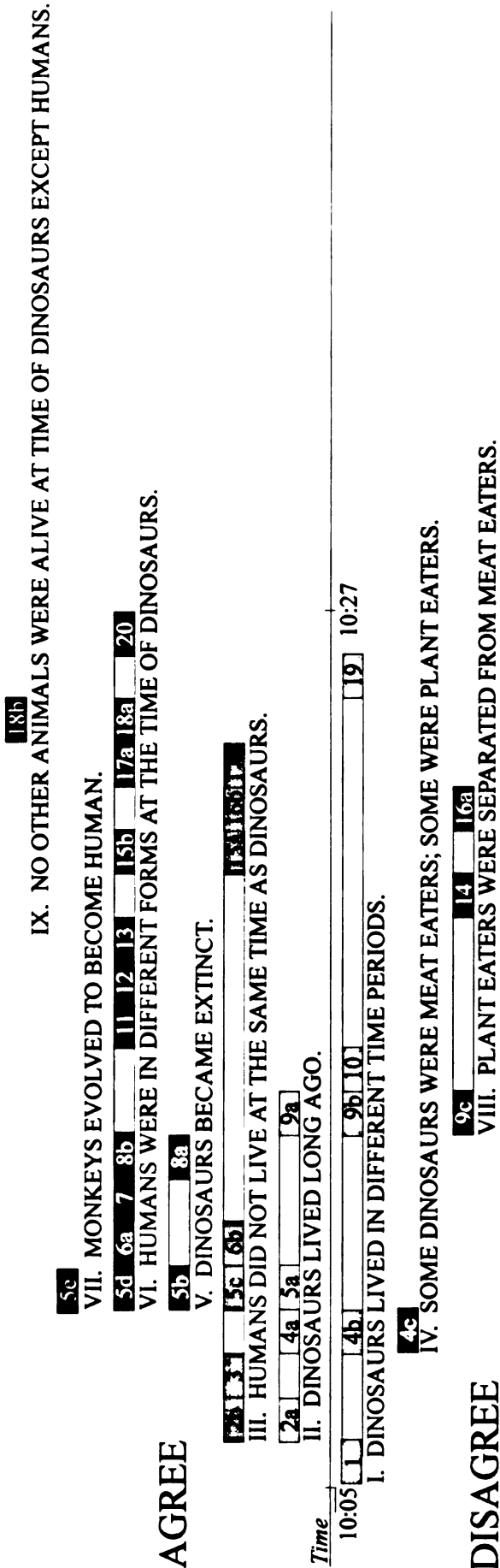
4c. Some dinosaurs were meat eaters, & some were plant eaters.

DISAGREE

IV. SOME DINOSAURS WERE MEAT EATERS; SOME WERE PLANT EATERS.

Figure 5.8 - Extended G2 Timeline: Section 1

Topic Statement: When did dinosaurs live? Did they live on earth all at the same time?



Speaker's Comments

Figure 5.9 - G2 Timeline: Increased Breadth through Productive Side Trips

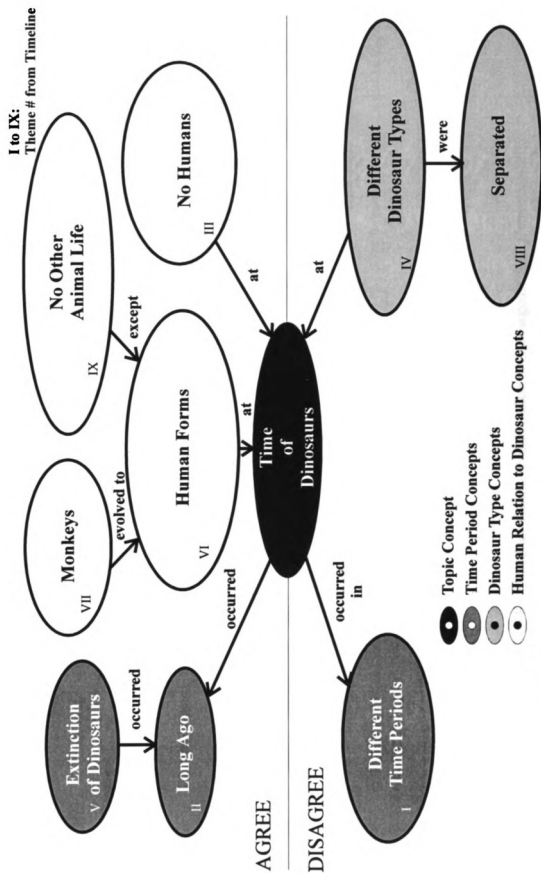
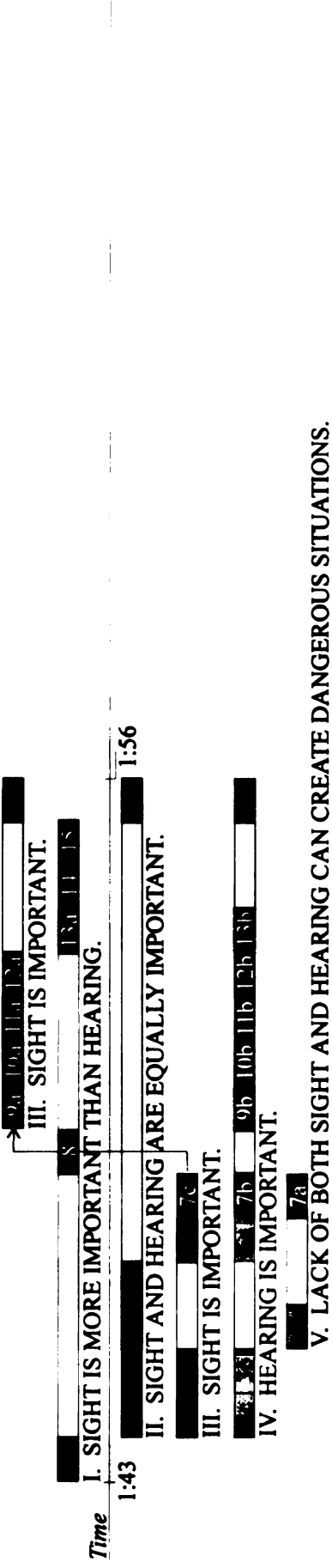


Figure 5.10 - G2 Concept Map: Increased Breadth through Productive Side Trips

Topic Statement: Sight is more important than hearing.

AGREE



DISAGREE

- # Girl's Comments
- Boy's Comments

Figure 5.11 - K1 Timeline: Gender Collaboration in Convergent Claim Conversation

Topic Statement: Air has a color.



DISAGREE

Girl's Comments

Boy's Comments

Figure 5.12 - G3 Timeline: Gender Collaboration in Divergent Claim Conversation

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**KNOWLEDGE, LANGUAGE AND SUBJECTIVITIES IN A DISCOURSE
COMMUNITY: IDEAS WE CAN LEARN FROM ELEMENTARY CHILDREN
ABOUT SCIENCE**

VOLUME II

By

Lori Ann Kurth

A DISSERTATION

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

DOCTOR OF PHILOSOPHY

Department of Teacher Education

2000

Introductions

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Chapter 6

LANGUAGE: NARRATIVE AND PARADIGMATIC FORMS OF TALK

Introduction

In this study I analyzed the modes of thought, narrative and/or paradigmatic (Bruner, 1986), students used to express their ideas about science. I wanted to investigate which forms of talk different students used for distinct topics at particular times. The semi-structured format and considerable amount of student responsibility and autonomy provided richness and freedom to the students' conversations in these classrooms. Students were given a great deal of freedom to express their scientific understanding in ways that were natural and made sense to them. These speech choices involved the use of either or both narrative and paradigmatic forms of talk as the students reasoned about the scientific issues under discussion. I hoped to better comprehend the speech forms which gave students access to the scientific conversations and enriched their understanding of scientific content. I developed the following objectives for this study.

1. Identify narrative and paradigmatic features of talk in students' science oral discourse.
2. Ascertain patterns (by gender, topic and time) for when students used narrative or paradigmatic forms of language expression.
3. Specifically analyze students' claims and reasons for predominant narrative and paradigmatic features.

Theoretical Perspectives

The research literature about discourse cited in chapter 4 is relevant to this

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analysis as well. In attempting to gain some understanding of the students' varied language patterns, I focused on a framework for studying the science conversations based on narrative and paradigmatic forms of talk. While paradigmatic talk has traditionally been used and valued in science classrooms (e.g., Driver, Newton & Osborne, 2000; Glynn & Takahashi, 1998; Snow & Kurland, 1996), more attention has been brought to narrative generally (Connelly & Clandinin, 1994; Dyson & Genishi, 1994; Egan, 1986; Lyle, 2000) and in science education (Louden, 1998; Taylor & Geelan, 1998; Venville & Milne, 1998; Wallace, 1998). I drew on Jerome Bruner's (1986) work distinguishing narrative and paradigmatic modes of thought and Stephen Toulmin's (1958) work on the paradigmatic mode, scientific argument.

Bruner distinguishes two modes of thought, narrative (story) and paradigmatic (argument), and characterizes each as follows:

A good story and a well-formed argument are different natural kinds. Both can be used as means for convincing another. Yet what they convince *of* is fundamentally different: arguments convince one of their truth, stories of their lifelikeness. The one verifies by eventual appeal to procedures for establishing formal and empirical proof. The other establishes not truth but verisimilitude. It has been claimed that the one is a refinement of or an abstraction from the other. But this must be either false or true only in the most unenlightening way (p. 11).

In detailing narrative, Bruner describes the construction of two landscapes in story.

One is the landscape of action, where the constituents are the arguments of action: agent, intention or goal, situation, instrument, something corresponding to a 'story grammar.' The other landscape is the landscape of consciousness: what those involved in the action know, think, or feel, or do not know, think, or feel. The two landscapes are essential and distinct. (p. 14)

Toulmin, on the other hand, focuses on the importance of claims and backing in the paradigmatic structure of scientific argument. "Logic is concerned with the soundness of the claims we make - with the solidity of the grounds we produce to support them, the

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firmness of the backing we provide for them - or, to change the metaphor, with the sort of *case* we present in defence of our claims” (p. 7).

Bruner further distinguishes the two modes by stating that paradigmatic thought deals with universal truths whereas narrative thought deals with particular connections. He references scientific hypotheses as starting as stories that then reach maturity through “a process of conversion into verifiability.” He asserts that paradigmatic thought seeks to abstract and universalize phenomena, so that in the end, it is unable to explain particulars (as narrative does). He suggests that scientists use stories but replace them when “causes can be substituted for them.” In any case, Bruner sees narrative and paradigmatic forms as distinct and separate modes of thought.

Methods

I selected the same subset of six out of 39 whole class science conversations for in-depth analysis of narrative and paradigmatic features that were used for the knowledge analyses. The six conversations represented both classrooms and a range of scientific topics, student discourse forms and time periods during the year. Each conversation was transcribed. I then listed narrative and paradigmatic features of language as described by Bruner (1986) and Toulmin (1958). Using this list, I identified narrative and paradigmatic features in the students’ talk along with other parameters including time of year, scientific topic, gender and cultural background using a Filemaker Pro database to organize categories. Upon initial perusal of the data, I noted which listed narrative and paradigmatic features from Bruner’s, Dyson and Genishi’s and Toulmin’s work were present in the students’ responses. I also added new features based on my characterizations of the students’ responses which were not well expressed by any of the

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features in the original list. I then shortened this larger list by selecting only the features which were most common in the students' responses. The complete list of features found in the literature and students' conversations is shown in Appendix E. The final condensed list of predominant narrative and paradigmatic features is shown in Table 6.1. A sample analysis of the narrative and paradigmatic features in a student's response is shown in Figure 6.1. Narrative segments are denoted with italics, and paradigmatic segments are underlined. Phrases with narrative and paradigmatic features are both italicized and underlined.

Following narrative and paradigmatic coding of the students' responses in the circle conversations, I next tallied the coded features using a Quattro Pro spreadsheet program. For each conversation, I tallied the total number of narrative and paradigmatic features expressed by the students. I also made tallies of each particular narrative and paradigmatic feature. I compared narrative and paradigmatic tallies by topic (life or physical science), gender, culture and time of year. I also analyzed the individual narrative and paradigmatic features for patterns across topics and separated features within the conversational structure of claims and reasons.

Children's Use of Narrative and Paradigmatic Modes

Mrs. G and Mr. K structured the circle conversations in a paradigmatic mode but allowed students the freedom to switch to a narrative mode. The teachers presented the topic sentence as a universal claim and then asked the students to frame their contributions by first agreeing or disagreeing with the topic statement or another student's response and then giving a reason. The students' responses, therefore, typically were structured in two segments, a claim followed by a reason. The first segment of the students' contributions

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fit into a mainly paradigmatic mode as they presented a *general claim* like the topic sentence, “Air has a color.” However, this segment also had a narrative *psychic reality of self* component as teachers asked students to frame their claims with the personal tags, “I agree” or “I disagree.” Students’ reasons for agreeing or disagreeing with the claim could follow traditional forms of scientific evidence or could be stated in a story form describing a particular, perhaps personal experience with real phenomena.

Results

Table 6.2 provides a descriptive overview of the conversations analyzed and summarizes the general predominance of narrative and paradigmatic elements in the students’ science conversations across classrooms, over the year and by topic. Students used both language forms appropriately but tended to use narrative forms of talk when referencing particular examples or personal experiences and paradigmatic talk when discussing abstract topics removed from their everyday lives. Primary trends are discussed in detail below. Trends over time are reported first in order to give the reader a contextualized understanding of the conversation flow. Then trends by topic are given followed by a breakdown of the students’ responses in terms of specific narrative and paradigmatic features within their claims and reasons. Finally, gender trends are discussed.

Trends over Time

There were particular trends in the quantity of narrative and paradigmatic features expressed by students over time. Students used both narrative and paradigmatic features throughout the year showing their competence with both language modes. The percentage of narrative features, however, decreased over time, while the percentage of paradigmatic

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features increased over time in both classrooms. Figure 6.2 shows the narrative and paradigmatic feature percentages over time in Mrs. G's class, and Figure 6.3 shows the feature percentages over time in Mr. K's class. Both teachers encouraged students to use a wide variety of nonfiction knowledge sources in stating their reasons as discussed in chapter 5. Despite this freedom of potential language forms, students may have learned from other contexts, such as reading science text books, the standard tendency for scientific language to be expressed in a paradigmatic mode. Even though students used the paradigmatic mode of expression more over the course of the school year, at all times, the students also made significant contributions to the science conversations with narrative expression. Examples and commentary from the beginning, middle and end of the school year show the complementary roles of narrative and paradigmatic language in the students' conversations.

Narrative and Paradigmatic Beginnings

Both Mr. K's and Mrs. G's students started the beginning of the year with narrative and paradigmatic features in their science conversations. For example, Mr. K's class used many narrative features in their reasons about the life science topic, "Sight is more important than hearing".

The transcript examples are arranged in tabular form with the coding of language features shown in the right column next to the corresponding transcript. Narrative and paradigmatic language codes are derived from the list in Table 6.1. In the transcript segments and corresponding codes, narrative features are italicized, and paradigmatic features are underlined. The student's response is segmented into separate phrases which individually confer meaning. The phrases are separated into rows in the "Transcript"

column and are consecutively numbered after the first phrase which follows the student pseudonym. Teacher comments, transcriber notes and uncoded student contributions including incomplete ideas or interruptions that were not formal turns are in plain type. A portion of the conversation about the topic statement, “Sight is more important than hearing,” follows.

Student	Transcript	Language Features
Natalie	<u>I agree with the statement</u>	<u>thinking</u> , <u>topic</u> <u>claim</u> , <u>universal</u>
2	<u>because, um, if you didn't, you couldn't hear</u> (pause), <u>if you couldn't hear, your friend could write a statement that she wanted to tell you or something, and you could see it.</u>	<u>lens</u> of <u>multiple</u> <u>perspectives</u> , <u>particular</u> , <u>reason</u>
Jill	<u>I agree, I agree and disagree with the statement.</u>	<u>thinking</u> , <u>particular</u> , <u>topic</u> <u>claim</u>
2	<u>I disagree with the statement</u>	<u>thinking</u> , <u>topic</u> <u>claim</u> , <u>universal</u>
3	<u>because if you were driving, if you were driving, you couldn't see where you were going, and, and you couldn't see, and you wouldn't know where you were going.</u>	<u>viewing</u> <u>lens</u> of <u>other</u> , <u>particular</u> , <u>reason</u>
4	<u>And if you couldn't hear, if you were walking on the train tracks, and somebody was trying to tell you that a train was coming, you wouldn't know because you would just think that everyone was waving at you.</u>	<u>Plot</u> , <u>lens</u> of <u>multiple</u> <u>perspectives</u> , <u>particular</u> , <u>reason</u>
Sook-Joo	<u>I agree and disagree</u>	<u>thinking</u> , <u>particular</u> , <u>topic</u> <u>claim</u>
2	<u>because, um, I agree and disagree</u>	<u>thinking</u> , <u>particular</u> , <u>topic</u> <u>claim</u>
3	<u>because, um, that, because if you didn't have hearing, you couldn't see somebody writing or somebody could just write it on a paper and let you know what they were trying to say.</u>	<u>lens</u> of <u>multiple</u> <u>perspectives</u> , <u>particular</u> , <u>reason</u>
4	<u>And I disagree with the statement</u>	<u>thinking</u> , <u>topic</u> <u>claim</u> , <u>universal</u>

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Student	Transcript	Language Features
5 Sook-Joo	<u>because if you didn't have hearing, you wouldn't really be able to see what they mean. Like Jill said, You would just think that the people might be just waving at you.</u>	<i>lens of multiple perspectives, particular, reason</i>

Natalie, Jill and Sook-Joo all created narrative *action* scenarios sometimes with *plot* elements which supported their claims that sight was or was not more important than hearing. They all discussed *particular* examples that were compelling reasons convincing the audience of their claims. The remainder of the conversation proceeded in a similar vein with students sharing specific examples of what might happen if a person did not possess sight or hearing. While none of the students were blind or deaf in this class, they did draw on specific, actual or supposed personal experiences in which they knew sight and hearing were important.

Mrs. G's class also used more narrative features in their reasons in a beginning of the year conversation about another life science topic, "All plants die in the winter." Audrey began the conversation by agreeing with the claim and sharing a narrative example of a particular personal experience she had had with a plant in the winter.

Student	Transcript	Language Features
Audrey	<u>I agree</u>	<i>thinking, topic claim, universal</i>
2	<u>Because my and my mom left a plant out in the winter to see if it would die, and when spring came, it died.</u>	<i>plot, particular, believable, personal experience, reason</i>

Similarly to the students in Mr. K's class, Audrey also expressed an *action* sequence with *plot* elements in recounting her experience with a plant. The details of her experience made it *believable*. One could relate to or imagine a similar experience. Other students shared similar personal experiences of caring for or

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observing plants during winter months. Later in the conversation, Darweshi gave an alternate type of reason with the paradigmatic element of a *logical* progression and the narrative element of a *particular*, single plant.

Student	Transcript	Language Features
Darweshi	<u>I, I agree that all plants die</u>	<i>thinking, topic claim, universal</i>
2	<u>because like, when snow comes down, it hits the, it hits the like, it hits the plant, and in the plant, and the plant, and it falls down because the snow is harder than the plant so it, so when it hits the plant, the plant goes down.</u>	<i>particular, reason, logical</i>

Darweshi told how the weather effects of snow (reason) could explain the death of all plants (topic claim). Though he described one *particular* plant, he explained it in *logical* terms rather than with a personal experience he had had with a specific plant.

Other students had balanced narrative and paradigmatic features within one reason. Alisha spoke of a personal, *particular* experience (narrative) she had had with plants, but at the same time, presented her story as a *test* (paradigmatic) showing that a plant in winter would die while a plant that was not in winter would live.

Student	Transcript	Language Features
Alisha	<u>I agree with Mila</u>	<i>thinking, viewing lens of other, topic claim, universal</i>
2	<u>because, because I had, I have two plants, and one, I put one out in the winter, and one is not in the winter, and the one that is in the winter, it died.</u>	<i>Plot, particular, personal experience, believable, reason, testable</i>

The beginning of the year showed a complex and sophisticated array of moves by the students. Mr. K's class primarily used narrative features in their reasons, but this may have been due to the students following the pattern of the first speakers who told compelling stories about the importance of sight and hearing. The topic sentence dealing

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with the everyday senses of sight and hearing may have lent itself well to personal, particular examples.

Mrs. G's class demonstrated that the students were competent with both narrative and paradigmatic language at the beginning of their second grade experiences. They used each form appropriately in their reasons, and some students provided interesting mixes of paradigmatic and narrative elements.

Movement toward Paradigmatic Talk with Significant, Non-Experiential Narratives

In the middle of the year, Mrs. G's class discussed the life science topic, "When did dinosaurs live? Did they all live at the same time?" At times, as in this example, the teachers would present the students with a question to be solved rather than a statement. The students were asked to make their own claims and give reasons. Certainly, this was a topic with which the students had no direct experience which may explain why students gave reasoning with a combination of narrative and paradigmatic features.

Student	Transcript	Language Features
Audrey	<i><u>I disagree</u></i>	<i>thinking, <u>topic claim</u>, <u>universal</u></i>
2	<i>Because at home, I have something about dinosaurs,</i>	<i>personal experience</i>
3	<i><u>and they have three different time periods.</u></i>	<i><u>topic claim, universal</u></i>
Mrs. G	Three different what?	
Audrey	<i><u>Three different time periods when the dinosaurs lived.</u></i>	<i><u>topic claim, universal</u></i>
Mrs. G	Do you want to explain more about that, or do you remember?	-
Audrey	<i>There's a game. You have to try and say 15 dinosaurs from all three different time periods</i>	<i>viewing lens of other (game), personal experience</i>

Audrey made an implicit claim that dinosaurs did not live at the same time and then elaborated with an explicit claim that they lived within three different time

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periods. Interestingly, she drew upon a personal experience at home, a game that had three dinosaur time periods, as a source for her claim. However, her actual spoken claims were paradigmatic, *universal* statements.

Juwan later challenged Audrey's claim of three time periods and attempted to strengthen his counterclaim by stating it was *verifiable* with a book he had read about dinosaurs.

Student	Transcript	Language Features
Juwan	<u>I think that dinosaurs lived THOUSANDS of years ago.</u>	<u>thinking, topic claim, universal</u>
2	And um, and, and, dinosaurs,	
3	<u>She (Audrey) said three periods,</u>	<u>viewing lens of other, topic claim, universal</u>
4	<u>but I have a book about dinosaurs, too.</u>	<u>viewing lens of other (book), verifiable</u>
5	<u>And it said that they had ten time periods,</u>	<u>viewing lens of other (book), topic claim, universal</u>
6	<u>and some dinosaurs were meat eaters, and some were plant eaters.</u>	<u>general, new claim</u>

Along with his *universal* claim that dinosaurs lived over ten time periods, Juwan added another *general* claim that some dinosaurs were meat eaters, and some were plant eaters. He also referenced the *viewing lens of others* (Audrey and a book) when stating his claims.

At one point in the conversation, the topic shifted to the issue of whether or not humans and dinosaurs were alive at the same time. Some students referenced the creation story as a valid narrative supporting their claims that humans and dinosaurs did not live at the same time. The conversation became heated as students had strong opinions on this topic. He-Ping attempted to sort out the various opinions by challenging others' potential fictional sources of stories and attempting to cite the "truthful" claims and reasons using strong *universal* (paradigmatic) statements. Steven then responded in a contrasting way by

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Student	Transcript	Language Features
He-Ping	<u>I agree with Darweshi and Unika and disagree with Nimah and Alisha</u>	thinking, viewing lens of multiple perspectives, <u>new claim, universal</u>
2	<u>because how can cavemen, I know that the real truth is that people and dinosaurs did not live at the same time.</u>	knowing, lifelike (human focus), <u>new claim, universal</u>
Nimah	(interrupts) There weren't people. They were cavemen.	-
He-Ping	Cavemen were not even	-
Alisha	(interrupts) Cavemen are not people!	-
He-Ping	<u>Cavemen were not even lived at the same time.</u>	<u>lifelike, new claim, universal</u>
4	It was the one who no one,	-
5	you guys just watch fantasy movies	viewing lens of others, believable
6	<u>Because how can cave people be at the same time as dinosaurs?</u>	<u>lifelike, reason, universal</u>
7	And Darweshi was the, and Unika was the only ones who were correct.	viewing lens of others, believable
Steven	<u>Well, I disagree with that</u>	thinking, <u>new claim, universal</u>
2	<u>Because God made the plant eaters first. Then he made the meat eaters before the two people were living.</u>	plot, particular, lifelike, <u>reason</u>

A similar pattern in the students' talk occurred in Mr. K's room in the middle of the year. The students were discussing the topic statement, "The sun is always shining". There were a few narrative features in students' reasons referencing personal observations sighting the sun. Mostly, though, students gave *universal*, *logical* (paradigmatic) reasons explaining the phenomena in terms of the movement of the sun in relation to the earth.

Student	Transcript	Language Features
Zan	<u>I agree with it</u> (the statement)	thinking, <u>topic claim, universal</u>
2	<u>because when the sun isn't shining on us, it's on the other side of the earth.</u>	lens of multiple perspectives, <u>personal experience, reason, logical, universal</u>

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Student	Transcript	Language Features
Sook-Joo	<u>I agree with the statement</u>	<u>thinking, topic claim, universal</u>
2	<u>Because I learned from my brother that the sun is always shining</u>	<u>knowing, viewing lens of other, believable, topic claim, universal</u>
3	<u>because it's on the other side of the earth, and at night, the moon is just covering the sun so it looks like</u> (rest inaudible).	<u>reason, universal</u>
Mr. K	You're going to have to repeat that because you sort of mumbled that last little part.	-
Sook-Joo	<u>The moon is just in the sun's way.</u>	<u>reason, universal</u>
Mr. K	Okay.	-
Evan	<u>I agree with that</u>	<u>Thinking, topic claim, universal</u>
2	<u>because in the morning the sun comes up, and in the day, the sun is up, and in the evening, the sun is going down, and in the night, I think the sun is on the other side,</u>	<u>Thinking, reason, logical, universal</u>
3	<u>but it is still shining.</u>	<u>topic claim, universal</u>
4	<u>It is reflecting the moon.</u>	<u>new claim, universal</u>

The students used naive, egocentric scientific reasoning citing the movement of the sun and the fact that the sun is always shining rather than the movement of the earth to explain night and day. However, they correctly identified the concepts of movement and the positions of the earth and sun as relevant and mostly spoke in a traditional scientific, paradigmatic mode using *logical*, generalizable arguments with *universal* reasons to support their claims.

As the students achieved consensus relatively quickly on this topic, Mr. K presented them with another related statement to discuss, "The stars are always shining." Students mostly shared similar scientific reasoning in a paradigmatic mode as they had with the statement, "The sun is always shining." They often agreed with the claim citing the *logical, universal* reason that the stars are not visible during the day because the sun is so bright. During this conversation, though, Zan shared a story she had heard from a

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Student	Transcript	Language Features
Zan	<u>I agree with the statement</u>	<u>thinking</u> , <u>topic</u> <u>claim</u> , <u>universal</u>
2	because in the outer space, in outer space, it is black up there.	reason (incomplete), <u>universal</u>
3	<u>and when the sun shines, when the sun shines, it scares away the stars, so they go away to the other side of the earth</u> (many children laugh).	plot, <u>anthropomorphism</u> (scared stars), <u>reason</u>

The students' laughter signaled that this was a different response from what anyone had previously said, and Mr. K stated that they would discuss this at the end of the conversation. Later, Mr. K later asked Zan about her intended meaning.

- Mr. K: One thing before we go, I wanted to talk, something that Zan said is that the sun comes out and chases the stars away. First of all, I want to ask if Zan really believes it. Do you really believe that the sun chases the stars away?
- Zan: No.
- Mr. K: No.
- Lucas: It's just a way to explain it.
- Mr. K: Well, but if you told some kindergartner that came in here, and you told them when the sun comes up, it chases the stars away, that kindergartner is going to think, oh, when the sun comes up, the stars run away. See, and then they would go home and tell everybody they knew the sun chases the stars away. Even though Zan doesn't believe it, and it might be a way to explain it, but was it a very good way?
- Students: No.
- Mr. K: Well, I asked Zan that because I think she was sort of being joking around when she said that, but I wanted to be sure.
- Zan: But I don't know how to explain.
- Mr. K: Well that's okay, all right?

In this excerpt, Mr. K made an important distinction between fictional and nonfictional narrative reasons. While both Mrs. G and Mr. K gave a lot of freedom to the students to express their reasons in a variety of language forms, they did not permit fictional reasons. It is interesting, however, to see Zan's purpose for using the fictional narrative when probed by Mr. K. She wanted to share a reason but did not possess a

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nonfictional explanation. Instead, she used perhaps the only explanation she knew, a mythical tale she had heard in her family. Mr. K drew attention to her fictional story and imposed an appropriate constraint that narratives must be nonfiction accounts.

Predominance of Paradigmatic Language with Key Narrative

Examples in End of the Year Physical Science Topics

Both classes were studying the physical science topics of water and air at the end of the year. Students primarily used paradigmatic modes of talk in these conversations. During one conversation, Mr. K's class discussed the topic statement, "There is water in air."

Student	Transcript	Language Features
Evan	<u>I agree with that</u>	<u>thinking, topic claim, universal</u>
2	<u>Because you can't see it</u>	<u>viewing lens of other, reason, general</u>
3	<u>because it's invisible.</u>	<u>reason, universal, abstract</u>
Lucas	<u>I agree with the statement and Evan that he's right</u>	<u>thinking, viewing lens of multiple perspectives, believable, topic claim, universal</u>
2	<u>that when water's in air, you can't see it.</u>	<u>viewing lens of other, reason, general</u>
3	<u>and it's invisible.</u>	<u>reason, abstract, universal</u>
Kyubok	<u>I agree with that statement</u>	<u>thinking, topic claim, universal</u>
2	<u>because there is water in the air,</u>	<u>topic claim, universal</u>
3	<u>but you just can't see it.</u>	<u>viewing lens of other, reason, general</u>
Zan	<u>I agree with the statement and with Evan</u>	<u>thinking, lens of multiple perspectives, topic claim, universal</u>
2	<u>because, um, because water sometimes can be invisible.</u>	<u>general, reason, abstract</u>

Mr. K's intern, Ms. C, was teaching the class that day and decided to probe the students about their reasons. As shown above, students were repeating the same abstract,

paradigmatic reasoning of water being invisible in air, and Ms. C encouraged them to elaborate.

Student	Transcript	Language Features
Ms. C	A lot of you are saying that about the invisible. I'd like to ask you then, "How do you know it's there then?" Maybe you can tell me about that.	-
Zan	<u>I saw it in a book.</u>	<u>knowing, reason, verifiable</u>
Yue	<u>I agree with the statement</u>	<u>thinking, topic claim, universal</u>
2	<u>because when water's in the air, it's a gas.</u>	<u>reason, abstract, universal</u>
Ms. C	Can you explain what the gas is to those of us who don't know?	-
Lucas	<u>A gas is like steam or water vapor.</u>	<u>simile, reason, general</u>
2	<u>It's like Yue said.</u>	<u>viewing lens of other</u>
Sook-Joo	<u>I agree with that statement</u>	<u>thinking, topic claim, universal</u>
2	<u>because water is in the air.</u>	<u>topic claim, universal</u>
3	<u>You just can't see it because it's a gas, and actually water that became a gas which is evaporated.</u>	<u>viewing lens of other, reason, general, abstract</u>
Lucas	<u>Um, what Sook-Joo was talking about,</u>	<u>viewing lens of other</u>
2	<u>it rises up in the air.</u>	<u>reason, universal, abstract</u>
3	<u>I'm just adding something to Sook-Joo's thing.</u>	<u>knowing, viewing lens of other</u>
4	<u>When it's evaporating, it's in the air and going back to the clouds.</u>	<u>reason, universal, abstract</u>

The students moved away from the word "invisible" but continued to speak in abstract, paradigmatic reasoning using terms such as gas, evaporation and water vapor. At this point Gary started a movement towards more concrete, particular narrative explanations.

Student	Transcript	Language Features
Gary	Um, Ms. C, when you said, "Can someone explain this invisible thing? How do you know it's there?"	-
1	<u>Well, um, you can feel the air 'cause blowing.</u>	<u>viewing lens of other, reason, general</u>
2	<u>and um, it's kind of wet</u>	<u>general, reason</u>

Student	Transcript	Language Features
3 Gary	<u>and you can feel it blowing in your face.</u>	viewing lens of other, <u>reason, general</u>
Ms. C	Can I feel it right now?	-
Students	Nooo.	-
Lucas	<u>Like when you're cooking the rice in a rice cooker. The steam goes out of it, and you can feel it like wet.</u>	particular, viewing lens of other, <u>reason</u>

The particular narrative example that Lucas shared of cooking rice was one that many students related to and referenced in their own reasons.

Student	Transcript	Language Features
Yue	<u>Every time my mother cooks rice, steam comes out of the pot.</u>	personal experience, <u>general</u>
Ms. C	Is it coming from the water or coming from the rice?	-
Students	(Loudly) <u>Water.</u>	<u>general, new claim</u>

This example of cooking rice allowed the students to productively discuss the abstract, paradigmatic claim of water in air with a concrete, particular narrative example. At the end of the discussion, Zan shared an example that solidified the claim of water in air by telling of a time when her mother forgot to put water in the rice pot.

Student	Transcript	Language Features
Yue	My question was, "Is steam water?"	
Zan	<u>Oh, um, I have an answer to your question.</u>	knowing
2	<u>Once, when my mom was cooking rice, she forgot, to put water inside, inside our pot. So, when we cooked it, no steam came out, but steam was supposed to come out, and then my mother saw that, um, she, she didn't put water in it,</u>	plot, particular, personal experience, <u>reason, logical</u>
3	<u>so I think that water makes the steam.</u>	thinking, <u>new claim, universal</u>
Gary	<u>I know.</u>	knowing, <u>new claim, universal</u>

Gary's affirmation vocalized the nodding heads of other students as Zan's story provided a compelling answer to their wondering if the steam coming out of the rice pot

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was, in fact, water. While this conversation proceeded with appropriate paradigmatic reasoning initially, the students were able to further their understanding of water in air by focusing their attention on a particular, shared everyday (narrative) experience of cooking.

Mrs. G's class discussed the statement, "Air has a color," more systematically using paradigmatic reasoning. However, there was a personal, narrative element to many of the students' reasoning as they prefaced their abstract, general points with a subjective tag citing personal experience such as "I saw..." or "When I look up in the sky..."

Student	Transcript	Language Features
Jason	<u>I disagree.</u>	<u>thinking, topic claim, universal</u>
Mrs. G	And tell why.	-
Jason	<u>I don't know.</u>	<u>knowing</u>
Mrs. G	What makes you think air has no color? What have you seen or done or read? Is it something you've seen yourself or something you've done or read about?	-
Dong-Yul	(interrupts) I don't see any color.	-
Jason	<u>Yeah, I don't see any color.</u>	<u>personal experience, reason, general</u>
Unika	<u>Um, I agree with Jason</u>	<u>thinking, viewing lens of other, topic claim, universal</u>
2	<u>because air doesn't have a color.</u>	<u>topic claim, universal</u>
3	<u>It's like you can't see it,</u>	<u>viewing lens of other, reason, general</u>
4	<u>and there's no color.</u>	<u>topic claim, universal</u>
5	<u>It's kind of like invisible,</u>	<u>reason, general, abstract</u>
6	<u>but I agree that there's no color.</u>	<u>thinking, topic claim, universal</u>
7	<u>It's just like white.</u>	<u>reason, general</u>
8	<u>You can't see it.</u>	<u>viewing lens of other, reason, general</u>
Jason	(interrupts) It's not even white. It's invisible.	-
Unika	<u>I know.</u>	<u>knowing, reason, universal</u>
Darweshi	<u>I agree with Unika</u>	<u>thinking, topic claim, universal</u>
2	<u>because, because there's air in this room,</u>	<u>particular, personal experience, reason</u>

Student	Transcript	Language Features
3 Darweshi	<u>and I agree with Jason.</u>	<i>thinking, viewing lens of other, <u>topic claim, universal</u></i>
4	<u>There's air in this room, but we cannot see the color because when you walk around.</u>	<i>particular, personal experience, lens of multiple perspectives, <u>reason</u></i>
5	<u>and you can see air in the sky. There's air everywhere you can find it, and when you kind of look up, there's no air.</u>	<i>lens of other, <u>reason, general</u></i>
6	<u>It's like it's invisible.</u>	<i><u>topic claim, general, abstract</u></i>

Mrs. G's response to Jason asking what of many possibilities made him think air had no color allowed for narrative or paradigmatic or a combination of both forms of talk. Most students followed Jason's approach of putting a subjective tag on a more general, paradigmatic reason. However, as when Mr. K's class discussed the statement, "There is water in air," Mrs. G's class also struggled with the use of abstract language such as the word "invisible." Unika's response demonstrates the difficulty students had in using paradigmatic language to explain their claims. He repeatedly restated the topic claim each time adding anew abstract reason as if struggling to come up with a reason that made sense. Darweshi, on the other hand, made his response more concrete and possibly comprehensible by appealing to the personal experience of looking at air in the room, an experience that his classmates shared.

Overall, students showed competent and complex use of both narrative and paradigmatic features in their science conversations from the beginning of the year. Many times the students mixed the features in their speech using the narrative and paradigmatic forms as complementary. There was a trend over time, though, for students to use more paradigmatic than narrative features in their talk. Narrative features, however, still provided concrete, tangible examples that aided students' struggles with removed, abstract

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Trends by Topic

Students expressed more narrative features when discussing life science topics and more paradigmatic features when discussing physical science topics. Figure 6.4 shows the percentage of narrative and paradigmatic features stated by students in each life science conversation. The percentage of narrative features in each conversation was greater than the percentage of paradigmatic features except for conversation G2 where the ratio of features was very close. Although conversation G2 was about a life science topic, it was a topic (time periods when dinosaurs lived) removed from students' everyday experiences. An example illustrates the predominance of narrative features in the life science conversations.

In conversation K1 about the statement, "Sight is more important than hearing," Sang-Ook began the discussion with the following statement.

Student	Transcript	Language Features
Sang-Ook	<u>Um, I agree</u>	<u>thinking</u> , <u>topic</u> <u>claim</u> , <u>universal</u>
2	<u>because, um, because when you want to say something, you can write it on a piece of paper.</u>	<u>lens of other, particular, reason</u>
3	<u>When other people are talking to you, they can write it on a paper, and you can read it.</u>	<u>lens of multiple perspectives, particular, reason</u>
4	<u>and you don't bump into anything.</u>	<u>lens of other, particular, reason</u>

Sang-Ook began with a *universal* claim and subjective tag showing his psychic reality of *thinking* when he said, "I agree (with the statement)." This format was the structure modeled by the teachers and was the standard response of most students. Sang-Ook then proceeded to cite a number of reasons to support his claim. Each of these

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reasons was a particular instance with subjective reference to the viewing lens of an other (*you*) or multiple perspectives (*people, they, and you*). Most of the other students followed Sang-Ook's lead by also referencing particular instances that supported their claims. The students provided a number of narrative examples to make their individual cases. While few reasons had paradigmatic features other than the structure of the reason itself, the accumulation of varied, powerful narrative reasons provided compelling arguments for and/or against the topic claim, "Sight is more important than hearing."

An opposite pattern was seen in the physical science conversations. Figure 6.5 illustrates the percentage of narrative and paradigmatic features in each physical science conversation analyzed. In all cases the percentage of paradigmatic features was far greater than the percentage of narrative features. An example of this pattern occurred in conversation G3 in which the students discussed the statement, "Air has a color." Most of the students stated their claim as an "I agree" or "I disagree" statement like Sang-Ook, but their reasons had a strongly paradigmatic character like Audrey's below.

Student	Transcript	Language Features
Audrey	<u>I disagree with Justin</u>	<i>thinking, viewing lens of other, <u>topic claim, universal</u></i>
2	<u>because blue is the color of the sky, not the air.</u>	<u>reason, universal</u>

In their claims students would often agree or disagree with another student rather than with the initial topic statement. This showed a subjectification component with the students expressing the *viewing lens of an other*. However, when considering the features in the students' reasons, many spoke with global, *universal* statements like Audrey rather than with *particular*, specific examples like Sang-Ook's in the life science conversation K1. These patterns suggest that the physical or life science character of the topic

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statements may have influenced the language features used by students in expressing their opinions.

Character and Features of Topic Claims

The character of the topic claims and reasons were very different as the above examples demonstrate. I, therefore, decided to examine them more closely as separate categories. Figure 6.6 depicts the percentage of narrative and paradigmatic features for the topic claim portion only of the students' responses in life science conversations. Paradigmatic features predominated in the topic claims, but narrative features still represented a significant component of the students' responses.

Figure 6.7 shows the percentage of narrative and paradigmatic features for the topic claim portion only of the students' responses in physical science conversations. Paradigmatic features again predominated in the topic claims, but they represented a far greater quantity than narrative features.

These patterns fit with the standard format in the classrooms of stating topic claims. Students would usually say, "I agree (or disagree) with the statement." This type of response contained the paradigmatic features, *topic claim* and *universal* (because the original statement by the teacher was always in a universal form) and the narrative feature, *psychic reality of self* [students' expression of their thinking when stating, "I agree (or disagree)"].

Looking more closely, Figures 6.8 and 6.9 show the specific narrative and paradigmatic features of the topic claims in the life science and physical science conversations. Narrative features are located on the left side of the figures, and paradigmatic features are on the right. Both figures show the predominance of *self* and

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universal features. (*Self* refers to the aggregate of characteristics such as knowing, thinking and feeling within the narrative category, *psychic reality of self*.) These data confirm the students' use of the expected conversational structure modeled by the teachers in which the students stated their individual agreement or disagreement (referring to *self*) with the stated topic claim (in a *universal* form).

There was a greater presence of narrative features in the students' life science claims than physical science claims. When considering the specific components in Figures 6.8 and 6.9, there is a greater percentage of *particular, personal experience* and *comprehensible* (narrative) features in the life science conversations as compared to the physical science conversations. Conversely, the *universal* (paradigmatic) feature was more predominant in the physical science conversations as compared to the life science conversations. Two examples illustrate these differences.

When discussing the life science statement, "All plants die in the winter," in Mrs. G's class, Mila put forth the following claim.

Student	Transcript	Language Features
Mila	<u>I agree that it dies in winter</u>	<i>thinking, particular, topic claim</i>
2	<u>but some places near the equator, they don't die...</u>	<i>general, topic claim</i>
Mrs. G	How about Malaysia (Mila's home country)?	-
Mila	<u>Yeah, they won't die.</u>	<i>particular, personal experience, topic claim</i>

Mila began her topic claim in typical fashion but then replaced the *universal* "all plants" with the *particular* word "it." Her next claim provides some explanation. She stated that plants do not die in some parts of the world near the equator. This is a *general* claim about some parts of the world. Mila expressed two different claims that were each

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dependent on a particular context rather than attempting a single, global claim. Her first claim using “it” may have been in reference to the Midwestern community where she lived at the time.

Realizing the value of Mila’s particular, contextual claims, Mrs. G probed her about her experiences in her home country of Malaysia, which Mila may have been alluding to, in her second claim. She stated, “...but some places near the equator, they don’t die.” Mila explicitly drew on her personal experience to then state another *particular* claim specifically about her home country of Malaysia. She responded, “Yeah, they won’t die.” The conversation continued with many students contextualizing and specifying their claims to particular experiences in their own home countries.

In contrast, most students stated their topic claims in the standard format modeled by Mr. K and Mrs. G. This pattern was especially strong in the physical science conversations. Lucas’ topic claim in the conversation about the statement, “The sun is always shining,” is typical of this trend.

Student	Transcript	Language Features
Lucas	<u>I agree</u>	<u>thinking,</u> <u>topic</u> <u>claim,</u> <u>universal</u>
2	because with,	-
3	<u>I agree that the sun is always shining.</u>	<u>thinking,</u> <u>topic</u> <u>claim,</u> <u>universal</u>

Lucas began by expressing his psychic reality of *thinking* with “I agree.” Sometimes stated but often implicit, as in this example, was the students’ agreement with the original topic claim (in a *universal* form). Often, students would repeat the topic claim as Lucas did in this example. He repeated the claim exactly as Mr. K initially stated it in a broad, *universal* (paradigmatic) form.

Students occasionally specified their topic claims as Mila did above (especially in

life science conversations) to a particular context sometimes drawing on personal experiences or explicitly attempting to make the claim comprehensible. However, most claims followed the standard form introduced by the teachers and exemplified by Lucas above.

Character and Features of Reasons

While topic claims followed a standard format, student reasons had much greater diversity. As discussed in chapter 5, teachers encouraged students to draw upon a wide variety of nonfiction knowledge sources from personal, out-of-school experiences to traditional, school references in their reasons.

In first examining the broad narrative and paradigmatic character of the reasons, there was a pattern that fits with the general trends of life science and physical science topics described earlier. There were a greater number of narrative features expressed by students in life science conversations and a greater number of paradigmatic features in physical science conversations. Figure 6.10 illustrates the percentage of narrative and paradigmatic features in life science reasons, and Figure 6.11 shows the percentage of narrative and paradigmatic features in physical science reasons.

As with the topic claims, I investigated the specific features which contributed to the larger narrative and paradigmatic patterns for the students' reasons. Figure 6.12 shows the breakdown of narrative and paradigmatic features for students' reasons in life science conversations, and Figure 6.13 shows the feature breakdown for physical science reasons. As previously, narrative features are on the left side of the diagrams, and paradigmatic features are on the right. In contrast to the topic claim features, there is far less reference to *self* (students' expression of their psychic reality) and more reference to *other* (which

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includes the subjectification categories of viewing lenses through an other or multiple perspectives), especially in life science conversations. This may indicate that students framed their claims from a personal, *subjective* position but then drew upon *other*, outside reasons to support their claims. The other predominant feature in the topic claims was the *universal* category. It was also a significant feature in students' reasons but present to a lesser degree. Like the claim features, the *universal* category was greater in physical science reasons than in life science reasons.

In considering other features, the narrative *particular* and *comprehensible* categories were prevalent in the life science reasons, and there was some expression of *action* such as plot elements along with *personal experiences*. There was a similar expression of *personal experiences* in the physical science reasons but far less expression of the *particular* feature. Instead, physical science reasons were more concentrated in the paradigmatic categories, *general*, *logical*, *abstract* and *universal*. The following examples illustrate these feature differences in life and physical science reasons.

While discussing the life science topic statement, "Sight is more important than hearing," in Mr. K's class, Arshad shared a response with multiple *particular* reasons seen through the *viewing lens of an other*.

Student	Transcript	Language Features
Arshad	<u>I agree with Evan</u>	<i>thinking, viewing lens of other, <u>topic claim</u>, <u>universal</u></i>
2	<u>because, um, you can see strangers passing by,</u>	<i>viewing lens of other, <u>particular</u>, <u>reason</u></i>
3	<u>or when your friend wants to say something,</u>	<i>viewing lens of other, <u>particular</u>, <u>reason</u></i>
4	<u>and you want to know how to play it, then you might not remember. You might not remember. You might not hear anything, and you will just play the game, and you will be out or something.</u>	<i>viewing lens of other, <u>particular</u>, <u>reason</u></i>

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In this life science illustration, Arshad shared a series of *particular* (narrative) examples as his reasons (lines 2-4) to support his claim of agreement with Evan (who had disagreed with the original statement). He framed his reasons from the point of view of *you*, a viewing lens of another person.

The trend toward paradigmatic features in physical science reasons is shown in the following example from a conversation about the statement, “Air has a color,” in Mrs. G’s class. Alisha shared a representative response.

Student	Transcript	Language Features
Alisha	<u>I agree with Audrey and Ellen,</u>	<i>thinking, viewing lens of others, <u>topic claim, universal</u></i>
2	<u>and I disagree with Justin,</u>	<i>thinking, viewing lens of others, <u>topic claim, universal</u></i>
3	<u>because blue is the sky, and see, the air doesn’t have any color.</u>	<u>reason, universal</u>

Alisha’s reason in line 3 is a sweeping, *universal* statement implying the lack of air color under all conditions. There is no subjectification component. Alisha does not directly refer to herself, any other viewing lens or a particular knowledge source.

Overall, there were some marked differences in the language forms students used in life science vs. physical science conversations. Life science conversations contained more narrative features generally while physical science conversations had more paradigmatic features. Examining the general character and particular features of students’ claims and reasons further specified these differences.

Students typically stated their claims with a greater number of paradigmatic features. The standard format was a *universal* statement tagged with an expression of the student’s psychic reality of *thinking*. There was a somewhat greater tendency for students

to use more narrative features (especially *particular*, *personal experience*, and *comprehensible* features) in their life science claims and more paradigmatic features (primarily the *universal* feature) in their physical science claims.

Principal differences by science topic were seen in the expression of students' reasons. There was a greater number of narrative features in the life science reasons and, conversely, a greater number of paradigmatic features in the physical science conversations. There was little reference to *self* but significant reference to *others* in all reasons, especially in the life science conversations. Life science reasons tended to be of specific, contextualized, *particular* (narrative) examples, while physical science reasons were broad, *universal* statements sometimes with *logical* or *abstract* (paradigmatic) components.

Trends by Gender

There were no qualitative differences in the types of narrative and paradigmatic features expressed by students according to gender. However, there was a difference in the quantity of turns and language features expressed by the students. Interestingly, the trends were different for each classroom. There were differences in the number of narrative and paradigmatic features in Mrs. G's class and differences in the number of turns in Mr. K's class.

The number of girls in Mrs. G's class was 15 (56 %), and the number of boys was 12 (44 %). Figure 6.14 shows the percentage of turns by girls and boys in Mrs. G's class over time. Girls possessed slightly fewer turns in the beginning and middle of the year, but the end of the year conversation G3 showed exactly equal numbers of turns. Altogether, the number of conversational turns seemed fairly equal between the genders.

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When considering the number of narrative and paradigmatic features expressed by students in the conversations, however, boys increasingly shared more features than girls did as the year progressed. Figure 6.15 shows the percentage of features expressed by girls and boys in Mrs. G's class over time.

Two examples from the middle of the year illustrate the differences in the number of features expressed by students. Mrs. G's class was discussing the questions, "When did dinosaurs live?" and "Did they live on earth all at the same time?"

As mentioned earlier, the students shifted the conversation to discuss the issues of whether humans lived at the same time as dinosaurs and what form the humans may have taken, cave people or monkeys. He-Ping, an Asian boy, offered the following extensive comments.

Student	Transcript	Language Features
He-Ping	<u>I agree with Darweshi and disagree with Juwan</u>	<u>thinking, viewing lens of other, new claim, universal</u>
2	<u>because dinosaurs lived 35 million years,</u>	<u>topic claim, universal</u>
3	<u>and they extinct down</u>	<u>new claim, universal</u>
4	<u>and Darweshi was right</u>	<u>viewing lens of other, believable</u>
5	<u>because dinosaurs did not live at the same time as humans</u>	<u>lifelike (human focus), new claim, universal</u>
6	<u>because they were already monkeys. Monkeys were the ones who have to became when they not even at land long ago. They were already from a monkey till when they, dinosaurs died, they grown, grown, grown, grown up to a human.</u>	<u>lifelike, reason, universal</u>

Nimah, a Middle Eastern girl, two turns later responded to the human form issue in the following way.

Student	Transcript	Language Features
Nimah	<u>There weren't monkeys.</u>	<u>new claim, universal</u>
2	<u>There were cavemen, cave people.</u>	<u>lifelike, new claim, universal</u>

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He-Ping expressed a total of 15 features in his turn while Nimah expressed a total of five features in hers. Though there were certainly individual differences in which some girls spoke extensively and some boys spoke briefly, the overall trend showed an increasing difference between the number of features expressed by boys and girls.

In Mr. K's class an opposite trend occurred. There were 9 (36 %) girls and 16 (64 %) boys in his class for conversation K1 and 11 (50 %) girls and 11 (50%) boys for conversations K2 and K3. Even though the number of girls present for the conversations increased over time, and the number of boys present decreased, the opposite pattern occurred for the number of turns (Figure 6.16). One possible explanation for this trend is the *gender clustering* of turns reported in chapter 5. Briefly, I observed a succession of same gender turns within the conversations. Once one gender obtained a turn, students tended to continue choosing next speakers of the same gender. Gender clustering (two or more same gender turns in a row) is seen in the profile of turns for each conversation shown below.

G = girl turn B = boy turn

K1: **B-B-B-B-B-B** G-G-G-G-G-G-G-G-G-B

K2: G-G **B-B-B-B** G-G **B-B** G-G B-G-B-G **B-B**

K3: **B-B-B** G-G-G B-G **B-B-B-B-B** G-G-G **B-B** G **B-B-B** G-B-G

In the first conversation K1 there were two large gender clusters, one boy cluster and a large girl cluster. In the middle of the year, there were three clusters of each gender. One large boy cluster (four turns) at this time resulted in more boys' turns for the conversation. Finally, at the end of the year, the boys succeeded in obtaining more turns with four turn clusters, while the girls received only two clusters of turns.

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Though the boys received more turns over time than the girls in Mr. K's class, the number of features expressed by both genders was similar unlike Mrs. G's class. Figure 6.17 shows the number of features expressed by girls and boys in Mr. K's class over time. By comparing Figures 6.16 and 6.17, one can see that the percentage of turns by each gender closely matches the percentage of expressed features by each.

In summary there were some interesting patterns according to gender in these analyses. Surprisingly, these trends were opposite for each classroom. In Mrs. G's class, girls and boys had fairly equal numbers of turns in their conversations, but boys expressed more narrative and paradigmatic features within their turns. In Mr. K's class, boys obtained more turns than girls in the conversation over time, but girls and boys expressed roughly the same number of narrative and paradigmatic features per turn.

Summary

There were narrative and paradigmatic patterns across the year, along topic lines, and according to gender. All students used narrative at the beginning of the year. For example, when Mr. K's students were discussing the biological statement, "Sight is more important than hearing," most of them switched from the paradigmatic style of the original statement to supporting it with stories of personal or potential experiences with real phenomena. Many students also showed use of paradigmatic and mixed narrative and paradigmatic forms.

Students moved towards more paradigmatic language throughout the year. When Mrs. G's students were discussing the abstract physical science statement, "Air has a color," at the end of the year, they maintained the paradigmatic form in their reasons citing universal, abstract truths about the color of air. However, narrative reasons often provided

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key, fruitful events for the students' conversations as when the students cited the concrete, particular example of steam coming from cooking rice when they discussed the statement, "There is water in air."

Patterns over time may have been linked to topics studied. Students used narrative to a slightly greater degree with life science topics and paradigmatic language more often with physical science topics. However, life science topics were taught at the beginning of the year, and physical science topics were taught at the year's end.

When looking at the character of topic claims and reasons, paradigmatic features predominated in topic claims. A closer analysis of the features within topic claims showed a strong emphasis on the paradigmatic *universal* feature. Additionally, the narrative features dealing with *psychic reality of self* were also prevalent in topic claims. These findings fit with the teacher-modeled format for expressing topic claims. Teachers initiated the topic claim format, "I agree or disagree (narrative *self* feature) with the statement (paradigmatic universal feature)."

Mostly, students followed the teachers' format for expressing topic claims. However, life science topic claims contained somewhat more narrative features than physical science claims. This trend was demonstrated when students would sometimes specify a claim to a particular context.

The character of students' reasons showed more diversity than their topic claims. Life science reasons had more narrative character, while physical science reasons had more paradigmatic character. A closer examination of the specific narrative and paradigmatic features revealed high use of *other, particular* and *comprehensible* narrative features in life science reasons and high use of *abstract, general, universal* and *logical*

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The narrative *self* and *other* features are particularly interesting as students mostly spoke from the perspective of their own *selves* in their topic claims but then switched to the perspective of an *other* in their reasons. This pattern may suggest that students were comfortable expressing a personal, subjective opinion about the topic claim presented to the whole class but then felt it necessary to reference an *other*, outside reason to support their claim. The structure of claims initiated by the teachers usually expected a personal response with the phrase, “I agree,” or “I disagree.” Students had much more freedom in the language structure of reasons, however, and so may have felt safer removing this contribution from their personal selves.

Experience base may have been an important factor in the narrative and paradigmatic feature differences between life and physical science conversations. Students may have felt closer to life science topics based on their experiences with the world. In the life science conversations, they were more likely to reference a specific, concrete experience or example with the narrative features of *plot* elements, *subjectification*, *particularity* and *believability* (making their experiences or examples *comprehensible*). However, when a concept was more removed from their experience as in the physical science conversations, they tended to give reasons in a paradigmatic mode with *abstract*, *general*, *universal* and *logical* features.

There were no noticeable qualitative differences by gender in narrative or paradigmatic expression. Nonetheless, there were quantitative differences in the number of turns and total number of narrative and paradigmatic features expressed by students according to gender. Surprisingly, these trends were different for each

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classroom. In Mrs. G's class, boys expressed more narrative and paradigmatic features per turn than girls did. In Mr. K's class, boys obtained more turns than girls did over time.

Discussion

The use of both narrative and paradigmatic features in students' conversations is one way to *expand* science discourse. Students used these features in a variety of ways in the conversations sometimes emphasizing narrative language, sometimes paradigmatic and also combining both language forms in interesting ways. A conversation might contain a number of different, compelling examples or personal experiences that supported a claim. On the other hand, students sometimes followed one logical, universal line of reasoning that was convincing and repeated by many speakers to the point of consensus. Teachers' encouragement of a diversity of language forms that were relevant to the topic at hand showed students that both narrative and paradigmatic language was permitted and valued in the classroom. Since there were no qualitative differences in the type of features used by students according to gender, these findings suggest that many students were comfortable and competent with both narrative and paradigmatic language. These conversations represent effective models for us to expand scientific discourse with the explicit, combined use of narrative and paradigmatic language.

Nonetheless, in other ways, the discourse was *constrained*. Students moved toward using more paradigmatic features in their conversations over time. Perhaps they learned in other contexts that paradigmatic language is the traditional mode used in formal science, and they attempted to adopt this as their primary language form in

their school talk. Also, students tended to use narrative language more in life science topics and paradigmatic language more in physical science topics. While this may be an expected finding considering that life science topics are often closer to students' concrete experiences, it represents a constraint to the language. In further work we might encourage the use of both language forms in all topic areas.

Finally, access to the conversations was limited according to gender. Mrs. G's boy students obtained longer turns in which they expressed more language features, while Mr. K's boy students received more turns than girls did over time. Each trend shows that boys had more opportunities to practice the discourse, both narrative and paradigmatic forms, than girls. These findings can help to make us more aware of these potential activities in classrooms, so that we can work to make science discourse more equitable for all students.

Considering evidence that children tend to learn in narrative styles (Egan, 1987), the use of the paradigmatic mode may be somewhat surprising. However, the blending of the two styles by the students is very interesting. One possibility is that it represents a transitional stage as students move from narrative to paradigmatic modes in school science. Another interpretation is that this conversational model provides students with the freedom to use both narrative and paradigmatic modes as best suits the context in which they are speaking. These conversations show that narrative and paradigmatic language can be used together in complementary, meaningful ways. The two modes do not need to be in opposition and can, in fact, enhance each other. Since many students become disinterested in science as they progress through school (and solely use the paradigmatic mode, O'Toole, 1996), more attention to the blending

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process of narrative and paradigmatic modes in science may be important in maintaining students' engagement.

Table 6.1 – Language Features

Narrative Language

A. STRUCTURE

1. Action (plot)
2. Consciousness
 - a. Psychic Reality of Self (expression of knowing, thinking or feeling)
 - b. Subjectification (viewing reality through a particular lens: self, other, multiple perspectives)

B. CHARACTERISTICS

1. Particular
2. Based on Personal Experience
3. Literary Features (e.g. simile, metaphor, hyperbole)

C. PURPOSE: to Make Experience Comprehensible

- a. Believable, Lifelike, Probable
- b. Not Testable

Paradigmatic Language

A. STRUCTURE: Argument

1. Claims
2. Reasons

B. CHARACTERISTICS

1. General or Universal
2. Abstract
3. Logical
4. Use of Analogies

C. PURPOSE: Justificatory

- a. Testable by Formal Procedures
- b. Verifiable

Table 6.2 – Overview of Language Features in Students' Science Conversations

Class Code	Time of Year	Topic Sentence	Science Topic	Total Narrative Features	Total Paradigmatic Features	Total # of Student Turns
G1	Beginning	All plants die in the winter. When did dinosaurs live?	Life	100	80	20
G2	Middle	Did they all live at the same time?	Life	99	107	20
G3	End	Air has a color	Physical	35	59	10
K1	Beginning	Sight is more important than hearing. The sun is always shining.	Life	93	74	16
K2	Middle	The stars are always shining.	Physical	51	113	18
K3	End	There is water in air.	Physical	66	141	25

Abbreviations:

G: Mrs. G's Class

K: Mr. K's Class

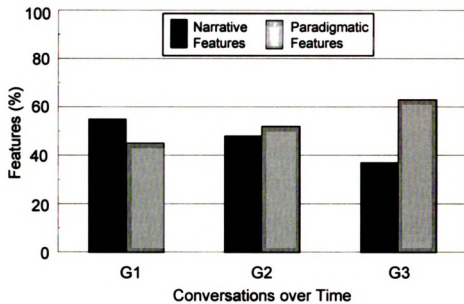


Figure 6.2 - Trends over Time in Mrs. G's Class

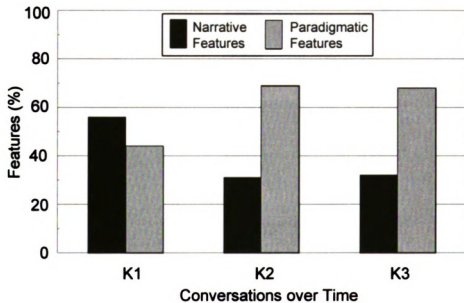


Figure 6.3 - Trends over Time in Mr. K's Class

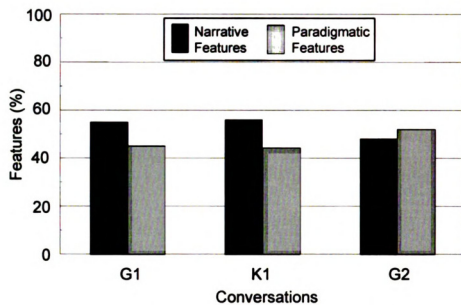


Figure 6.4 - Trends in Life Science Topics

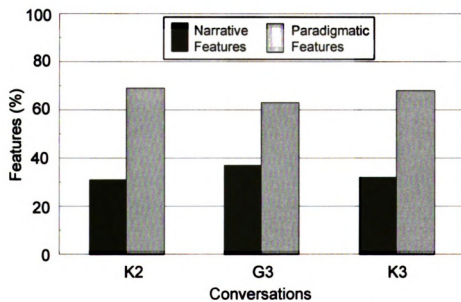


Figure 6.5 - Trends in Physical Science Topics

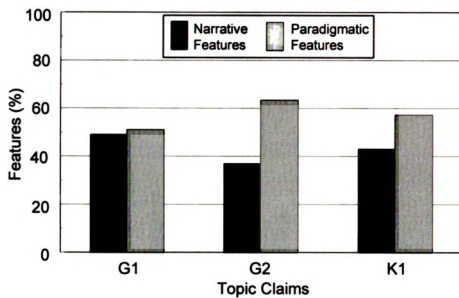


Figure 6.6 - Character of Life Science Topic Claims

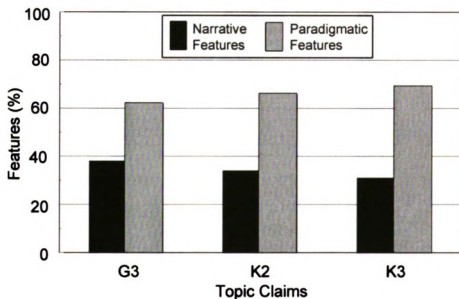


Figure 6.7 - Character of Physical Science Topic Claims

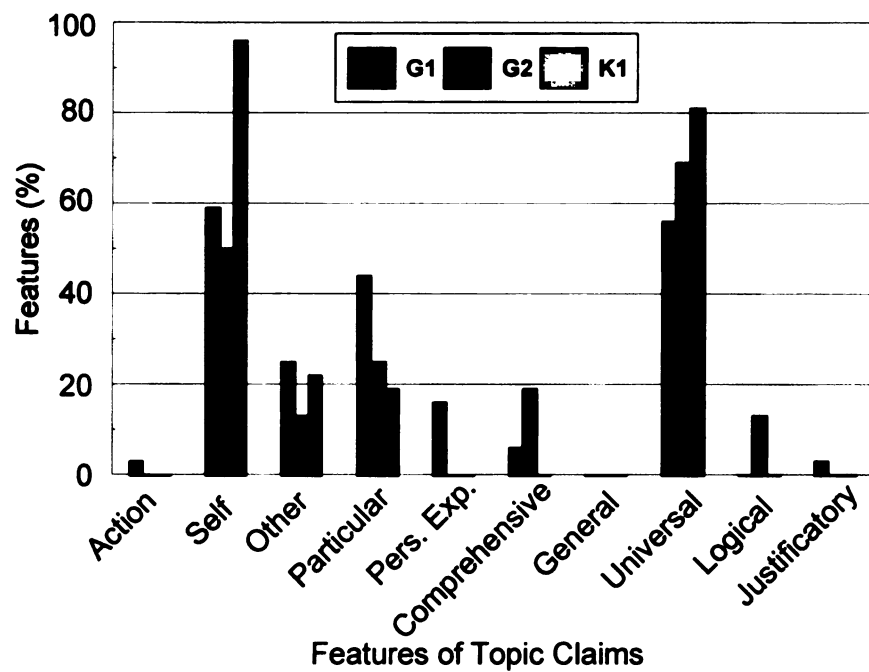


Figure 6.8 - Features of Life Science Topic Claims

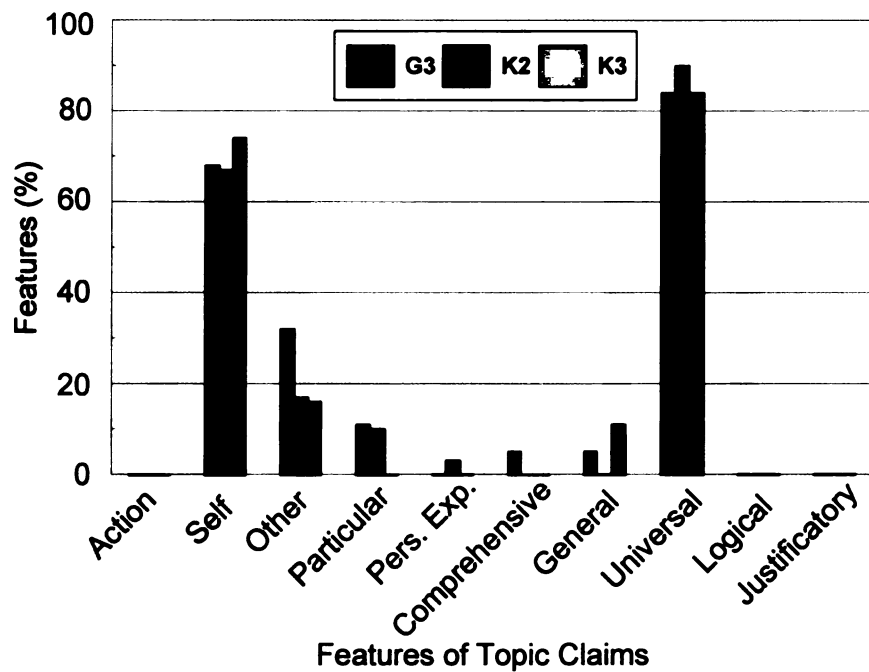


Figure 6.9 - Features of Physical Science Topic Claims

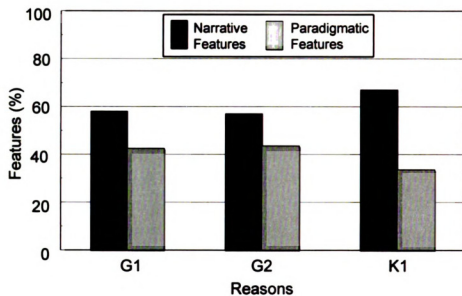


Figure 6.10 - Character of Life Science Reasons

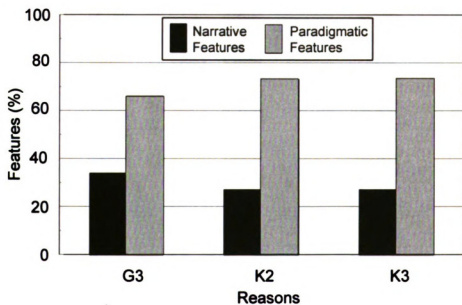


Figure 6.11 - Character of Physical Science Reasons

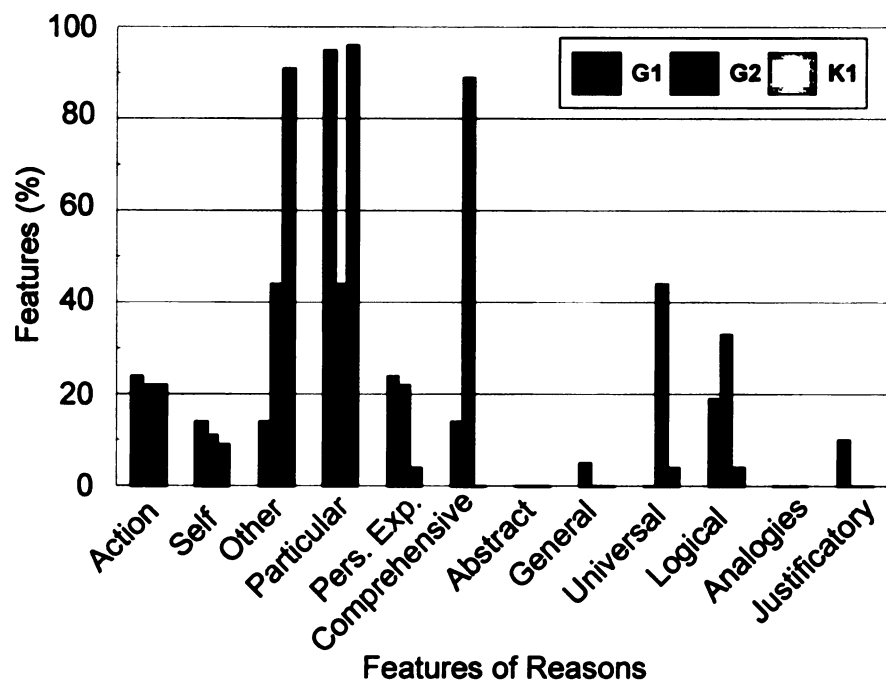


Figure 6.12 - Features of Life Science Reasons

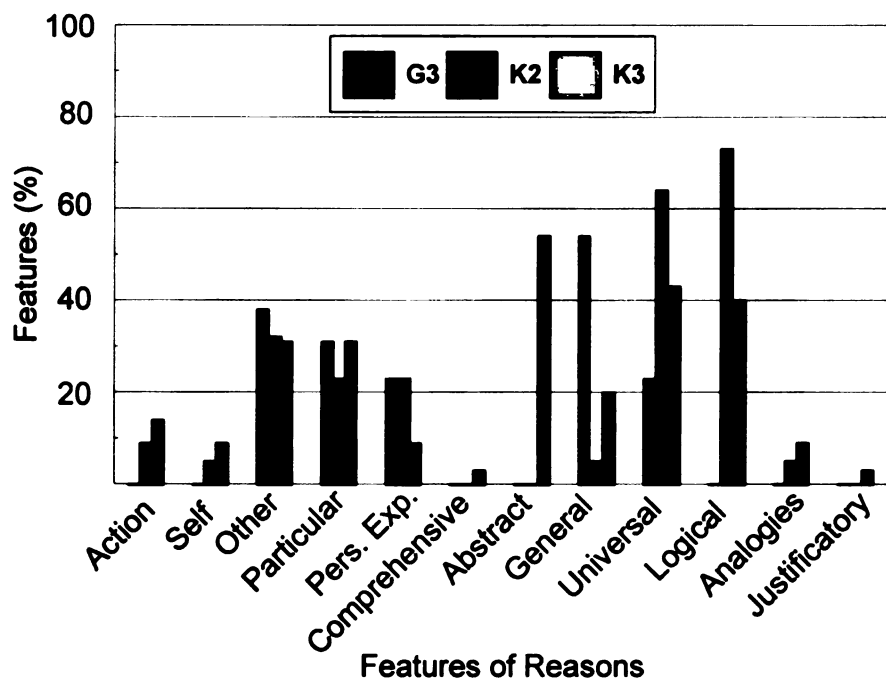


Figure 6.13 - Features of Physical Science Reasons

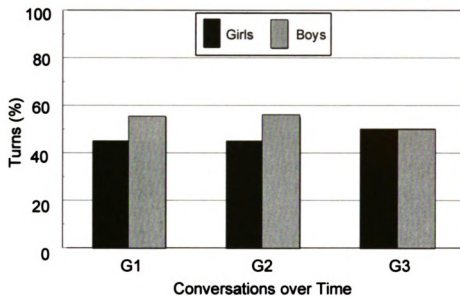


Figure 6.14 - Conversational Turns by Gender in Mrs. G's Class

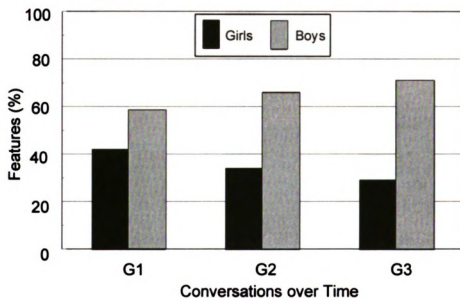


Figure 6.15 - Total Expressed Features by Gender in Mrs. G's Class

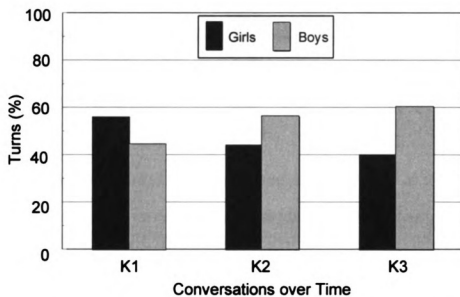


Figure 6.16 - Conversational Turns by Gender in Mr. K's Class

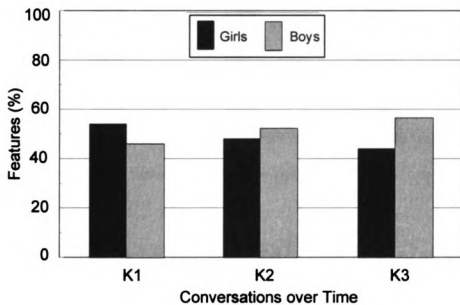


Figure 6.17 - Total Expressed Features by Gender in Mr. K's Class

Chapter 7

SUBJECTIVITIES: STUDENTS' PERSONAL EXPRESSIONS IN SCIENCE JOURNALS

Introduction

In this analysis I looked at elementary students' perceptions of science in their writing and drawing. As I turned my attention to students' written literacy, I looked for potentially overlapping and complementary features to the conversational components. In particular, I was interested in the personal expressions (subjectivities) of the students in their journal writing and drawing and how students integrated their subjectivities with science knowledge and language. In addition, I addressed students' use of journals compared to their use of oral discourse and situated the work of students' journal writing within the larger context of science and literacy in their classrooms. I developed the following objectives for this study.

1. Identify the personal and social observations and characteristics including human, emotional, gender, cultural, etc. themes that students express in their journal writing and drawing.
2. Ascertain patterns (by gender, topic and time) for when students used personal expressions in their science journals.
3. Describe how subjective themes are integrated with knowledge and language in students' journals.

Theoretical Perspectives

Feminist and sociocultural researchers have specifically addressed the intertwined concepts of subjectivities, positions and identities. Davies (1989) defines subjectivities as follows:

Within this model, who one is is always an open question with a shifting answer depending upon the positions made available within one's own and others' discursive practices and within those practices, the stories through which we make sense of our own and others' lives...

Each of these possible selves can be internally contradictory or contradictory with other possible selves located in different story-lines. Like history, the person is disjointed until and unless located in a story. Since many stories can be told even of the same event, then we each have many possible coherent selves (p. 229).

Weiler (1988) also asks us to consider the shifting nature of subjectivities drawing on Bakhtin's (1981) meaning that "each individual's subjectivity itself is constantly being redefined as meaning is asserted, contested, affirmed, or denied" (p. 129). The New London Group (1996) suggests that "learning processes need to recruit, rather than attempt to ignore and erase, the different *subjectivities* - interests, intentions, commitments, and purposes - students bring to learning" (p. 72). McLaughlin and Heath (1993) discuss identity as "multiple dimensions" which "situate meaning and circumstance" (p. 213). Hazelwood (1996), also working from a conception of social identities as multi-dimensional, found that students' identities characterize their marginality in science. She calls for a "politics of inclusion in science which focuses on identities, rather than in depth examinations of subject matter content." All of these rich variations have formed a basis for my understanding of the expression of subjectivities by elementary students in their science writing and drawing. Realizing that it would not be possible to capture the full complexity of students' subjectivities, I decided to focus only on tangible features that would be visible in students' writing and drawing. I, therefore,

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decided to define subjectivities for this analysis as students' personal and social observations and characteristics.

Methods

I began analysis of the student science journals by first perusing all entries and making a preliminary listing of emergent themes that were present across multiple journals. I then chose a subset of twenty student journals for closer analysis. I chose the subset of journals to be representative of the class diversity in terms of gender, cultural background, English use and participation patterns in conversations and journal writing. I compared students' levels of discourse in journals to discourse levels in classroom conversations and then recorded ratings of low, moderate and high levels for quantity of discourse expressed by students in each venue. In addition, I noted students' familiarity with English based on English as a Second Language categories (beginning, intermediate, high, native). A brief profile of each student in the subset analysis is given in Table 7.1.

For the subset analysis, I examined each journal entry holistically and gave a broad description of the entry. Then I carefully studied each journal entry in detail and identified and listed specific, emergent themes along with evidence from the journal entry supporting each theme. Broad descriptions of each journal entry, specific themes and evidence for themes were recorded in a FileMaker Pro database. I classified each individual theme within the broad categories of subjectivities, language and knowledge. A sample student journal page that was analyzed is shown in Figure 7.1. The accompanying theme analysis for this journal page is shown in Figure 7.2.

Following the coding of themes in the students' journals, I analyzed interviews of students whose journals were included in the subset analysis. During interviews I had asked students about the general nature of journal writing in their classrooms and to

describe and explain particular journal entries usually of their choice. I modified journal theme codes or evidence to include new information conveyed by students in the interviews.

I next tallied specific features of the themes in the subjectivities category which became the focus of this analysis. I first tallied the total number of journal entries along with the subset of journal entries containing subjectivities themes. I next subdivided the total journal entries and journal entries with subjectivities themes into the categories of gender, topic and time of year. For each category I compared the number of journal entries with subjectivities themes to the total number of journal entries and expressed the comparison as a percentage. I also tallied the number of specific subjectivities themes for each of the above categories. I determined patterns for the occurrence of the set of subjectivities themes as well as specific themes by gender, topic and time of year.

Results

As I identified themes within the students' journals, I became most interested in the number and variety of themes within the *subjectivities* category. In my initial perusal of the data, I found many personal elements such as self-drawings of students and the use of personal pronouns. This style of science writing by students is different from that of traditional scientists but is representative of alternative views of science such as feminist critiques (Keller, 1985; Harding, 1986; Hubbard, 1989) that are more inclusive to people who have been traditionally marginalized by science. I was particularly interested in subjectivities in this study because of their notable absence from many scientific writings and drawings in school and professional science settings.

I also expected and found many *knowledge* themes related to the scientific processes and content which the students were studying. Unlike conventional science

texts, however, the students expressed their science knowledge in very active forms in their journals. With the teachers' emphasis on discourse in science, I expected and found many *language* themes within the students' journals. As described previously, students freely talked with one another while writing in their journals. Somewhat surprisingly, however, students also explicitly portrayed *conversation* in their journal writing and drawing.

I first report the general trends for the occurrence of subjectivities themes in student journals by gender, topic and time of year. I next discuss the prevalence of specific subjectivities themes with examples illustrating each theme. I then consider the integration of subjectivities themes with knowledge and language journal themes in which students present a holistic view of science in their writing and drawing. Finally, I locate the journals within the larger context of the classroom discourse.

Trends in Subjectivities Themes

The subset of journal entries with subjectivities themes, the total number of journal entries and the frequency (in percent) of journal entries with subjectivities themes are reported in Table 7.2 below.

Table 7.2 – Trends in the Presence of Subjectivities Themes in Journals

Category	Number of Journal Entries with Subjectivities Themes	Total Number of Journal Entries	Frequency of Journal Entries with Subjectivities Themes (%)
All Journals	283	457	62
Gender			
Girls	168	250	67
Boys	115	207	56
Topic			
Life Science	81	110	74
Physical Science	202	347	58
Time of Year			
Beginning	146	258	57
Middle	59	87	68
End	78	112	70

Overall, a majority of journal entries (62 %) contained subjectivities themes indicating that students saw these features as routine and perhaps necessary components of their journal writing and drawing.

Girls expressed personal and social observations and characteristics more often (67 %) than boys (56 %). This pattern may show the effects of girls socialized to value personal expression more than boys. However, boys' expression of subjectivities in many journal entries indicates a significant valuing of personal expression in science at this time in their lives. Overall, both genders expressed subjectivities themes in a majority of their journal entries.

As might be expected, students expressed subjectivities themes to a greater degree in life science topics (74 %) than physical science topics (58 %). By their nature life science topics concern themselves with living things including humans. However, other than a short unit about human senses, the life science topics in these classrooms dealt mostly with plants and animals other than humans. Therefore, the life science topics, in

and of themselves, did not require personal expressions by the students. Students, however, often actively included themselves as essential parts of their life science journal entries. Likewise, though to a lesser degree than life science, students conveyed many personal expressions in their physical science journal entries. While physical science topics are often considered as abstracted from human experience, these students still explicitly included themselves in a majority of their entries.

Looking across the year, the frequency of journal entries with subjectivities themes increased from 57 % to 70 %. Students did draw and write about their personal expressions from the very beginning of the year indicating that they valued personal expression in science from the time they first entered the classroom. However, the increased presence of subjectivities in the students' journals over time may suggest that the teachers and students in the classroom community recognized and supported personal expression in science writing and drawing. The trend may also represent students' increasing personal engagement with science over the school year.

Specific Subjectivities Themes

Major *subjectivities* themes included *self and human elements*, *thinking*, *emotions*, *gender marking*, *culture*, *collaboration and interaction* and *flexible student and teacher roles*. The frequencies of the individual themes are shown in Figure 7.3. The most prevalent theme was *self and human elements* representing nearly 50 % of the *subjectivities* themes in the student journals. The second most common theme was *emotions* (15 % of all *subjectivities* themes). The themes of *thinking*, *gender* and *collaboration and interaction* had similar frequencies (approximately 10 % each of all *subjectivities* themes). Few *culture* and *flexible student and teacher roles* themes were found (1 and 3 %, respectively). Little differences were found in specific *subjectivities*

themes according to gender, topic or time. Complete tallies and frequencies of specific subjectivities themes for the analyzed categories are reported in Table 7.3.

Descriptions and examples of each theme follow. To protect student identities, names were blocked out in example journal entries.

Self and Human Elements Theme

Students portrayed themselves or other personal elements in their science drawings sometimes labeling the drawings with their names or the word *me*. They often began their text with the word *I*. Many times they also included other people or human features in their journals. In addition, students showed ownership of their scientific investigations through the use of such *self and human* words as *my* and *we*.

For example, in one journal writing exercise Mrs. G and Mr. K asked students to draw or write about an experiment they had just conducted separating a heterogeneous sand mixture into differently sized particles. Throughout his journal entry Boseda included himself as an integral part of the activity (Figure 7.4). He began his text with the word *I* stating what he had seen, “*I saw sand.*” He next reported what he had done again putting himself in the text with the word *I*, “*I separated sand particles.*” He then drew the results of the experiment, three diagrams of differently sized sand particles (small, medium and large). Finally, he again included *himself* in the entry drawing a picture of his physical *self* in the active process of separating the sand particles. The use of the word *I* in his text and the drawing of Boseda doing the experiment illustrate the *self and human elements* theme. Students often represented *themselves* and *others*, both in text and drawings throughout their science journals.

In another example, I asked Natalie about some journal entries that included personal and human elements. We then looked at an entry that did not appear to have a

picture of her or any other human element in it (Figure 7.5). Her class had been working on a science unit about physical changes in matter. In this journal entry, she described how liquid could be changed to a solid by putting it into a freezer and then how a solid could be changed back into liquid by taking it out of the freezer.

Later in the interview, we were discussing the importance of a person holding a balloon so that it would not fly away in a journal entry from the same matter unit in which the students were asked to give examples of a solid, liquid and gas (Figure 7.6). At that point Natalie informed me that, in fact, there was a human presence in the previously discussed entry (Figure 7.5), a *hand* that was essential to her diagram.

Natalie: And then for gas, I put balloon, and then I put a picture of a balloon and somebody holding it. And sometimes I get mixed up with doing like their hands way up here, and then sometimes the string is far away, and then you're like, you have to make the person's arm really long (Figure 7.6).

Lori: Well, can you tell me why you put a person in this picture? I noticed there wasn't a person on the other page (Figure 7.5 that we had also talked about concerning states of matter).

Natalie: Well, I put a person in this one (Figure 7.6) because it's a balloon, and it would float away, you know, and like if it was real in the picture it would float away. So it seems more important to put a person because it might just float away. And, on this page (Figure 7.5, that I said there was no person in), right here, that's a hand. I sort of messed up.

Lori: What's the hand doing?

Natalie: It's taking, well, I didn't even see. I drew the refrigerator, and then I drew this closed, and then I realized, "How are they going to be able to get the ice cubes out?" So then I did this, and, it's just showing that they can take it out (with the *hand*), and then they're going to put it in the microwave.

Lori: I see. So, do you think it's important to have the hand in that one, too?

Natalie: Yeah, because if they were taking it out, there's no hand, and it might just drop on the floor.

Natalie seemed puzzled at my questions about a human presence in her journal. To her it was obvious that human elements were necessary components to make these journal entries meaningful.

While most children echoed Natalie's sentiments about the necessity of themselves and other people or personal and human elements (like a *hand*) in their journal drawings, a new student Kirk was notable in including few personal or human references in his journal. When asked about a similar entry to Natalie's in which he gave examples of a solid, liquid and gas (Figure 7.7, bottom of page), he said that humans were not needed in his drawings.

- Kirk: When she [teacher] said, "Draw a picture," I went, "Okay, I'll draw a picture." And then I said, "What should I draw? I know. I'll just draw a picture with nothing on it, no people and just the forms of matter."
- Lori: Ah, and why didn't you put any people in it?
- Kirk: 'Cause why should I when all you have to do is that.
- Lori: Okay, so, I know that sometimes people do put people in their journals. Do you ever put people in yours?
- Kirk: Sometimes, I put people in there.
- Lori: When would be a time when you would want to put a person in?
- Kirk: When I'm just drawing a regular picture for my writing. Sometimes that gives me a better idea what I could write.
- Lori: Oh, for your personal journal?
- Kirk: Yeah.
- Lori: Would you ever draw a person in your science journal?
- Kirk: Actually, I never did as you can see. I never did yet.
- Lori: Oh, yeah. Do you think you might ever?
- Kirk: I don't think I will, 'cause why would you have to?

In the entry discussed above (Figure 7.7, bottom of page), Kirk did repeatedly use the word *you* in his text describing the three phases of matter. His text for this entry stated

Liquid is some thing that *you* can pore (pour). Solid is some thing hard that *you* can't poke through. Gas is some thing that *you* can't see. Tha(t) is what matter is! (Kirk's journal, January, 1997)

While he did not include a physical person in his drawing, his writing did make reference to a person's perception of matter by describing each phase in reference to the way a human (*you*) would interact with it. For the most part, however, Kirk's entries were much more similar to traditional scientific writing and drawing than to his

classmates' journals. As a new student he may have been less familiar or comfortable with the more personal, humanistic patterns expressed by the other students in his classroom.

Thinking Theme

Students sometimes explicitly referenced their own thought processes in their science journals. Most often *thinking* was expressed in text through the use of the phrase *I learned* followed by a scientific idea students were studying. Students also prefaced science ideas they had studied with the phrases *I know* or *I think*. In a few instances students would use the circle conversation convention of stating *I agree* or *I disagree* with a particular claim or another student. On some occasions students would pose science questions they were wondering about in their journals.

A page from Evan's journal (Figure 7.8) exemplifies a typical entry illustrating the *thinking* theme. Evan's class had been studying frogs and toads, and he wrote a series of sentences, some beginning with *I learned*, which described the science ideas he had studied. He also provided an illustration for each science idea learned regarding the characteristics of frogs and toads.

Rati's journal entry (Figure 7.9), written during a unit about the solar system, began in a similar way to Evan's. She first made a statement beginning with *I know* followed by the scientific idea that "Uranus has rings". She then elaborated her *thought* processes by stating that she had originally forgotten this idea. When Mr. K had questioned another student, Rati's memory had been prompted, and she again remembered the idea. She used a significant part of her entry to describe her thinking processes concerning the stated scientific idea that "Uranus has rings."

Another example was found during the beginning of the year for a unit in which

groups of students were assigned particular habitats to study. As part of his investigation of the grasslands habitat, Xiaoping asked a question about an animal in his habitat (Figure 7.10) rather than simply restating science knowledge he had learned. He was interested in knowing how many teeth tigers have. Similar explicit reflections of students' thinking and knowledge occurred to some degree throughout the journals.

Emotions Theme

Students often wrote their feelings about the experiments they were conducting and displayed *emotional* expressions (such as smiling) on the faces of the people in their drawings. Most students enjoyed science and frequently wrote about the fun they had and made explicit statements that they liked science.

Jae-Hwa's journal contained a typical entry illustrating the *emotions* theme. In a trip to a local science museum, Jae-Hwa wrote about the museum being "fun," and that making slime was "cool" (Figure 7.11). In her drawing of the trip, she showed many students with smiles on their faces, and the teacher (larger figure) smiling as well.

In another example, Hyun-Shik wrote both about his good feelings doing small group work on ocean habitats and about his feelings that science was boring at the beginning of the unit (Figure 7.12). He shared his thoughts about this entry in an interview.

- Lori: It's seems to me you wrote a lot about your feelings this day when you wrote about the ocean group. There were so many cool things you wrote. You liked to draw cool things. It just seemed like it was, "Wow!" Everything looked really cool, and you said you liked science. You liked to draw. Oh, but this first day of science, it was boring. It was boring and boring. Do you remember about that, why it was boring?
- Hyun-Shik: Because I didn't know much about them, and it was boring because I couldn't tell, I didn't know how to do about it, and I thought it was boring because I don't know much about them because I can't explain what I know.
- Lori: About the ocean habitat?

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Hyun-Shik: Yeah.

Lori: I see. So that was hard. Now tell me what was cool. You also have that a lot of things were cool that day.

Hyun-Shik: Because there are alligators on ponds.

Lori: Ah, yeah, and that was a different group.

Hyun-Shik: Yeah, that was a different group.

Lori: Okay, but they were cool? You saw some other kids drawing alligators?

Hyun-Shik: Yeah, Mr. K's class...

Lori: Why did you write about the cool things that you saw and some of the boring things that you did?

Hyun-Shik: Because I like the cool stuff, and I wanted to tell how I felt when I was starting on science the first time.

Lori: Do you think it's important for our students to put how they feel about science in their journals?

Hyun-Shik: Yeah.

Lori: Why is that important?

Hyun-Shik: Because they don't know if you're boring, or you're excited.

Lori: Mmhmm, and do you think it helps the teacher if they know if it's boring or exciting?

Hyun-Shik: Yeah.

Lori: How would that help the teacher?

Hyun-Shik: If you write about it.

Lori: And that can help their teaching if they know?

Hyun-Shik: Yeah.

Hyun-Shik's journal writing and talk during the interview showed his comfort level in expressing all of his feelings about his science experiences. He thought it was important to write about his emotions in his journal and that these thoughts, good and bad would be helpful to his teacher. While most students' emotional expressions were enthusiastic about liking science, Hyun-Shik's example indicates that expressions of all feelings about science were respected and valued in the classroom community.

Gender Marking Theme

Students made clear gender markings of the people in their diagrams by hair length and style, clothing and naming particular students. They frequently drew other students along with themselves in their journals. Students more often included students of the same gender rather than the opposite gender in their diagrams. Sometimes students

would compose entire drawings of the same gender students or place opposite gender students at some distance from same gender students.

In a journal writing exercise at the beginning of the year, Mr. K and Mrs. G asked students to describe some movement and to explain what caused the movement. Rebecca drew and wrote about a real life example of swinging (Figure 7.13). Like most students she clearly marked the gender of the girls in her drawing with long hair, hair bows and dresses. Boys were typically shown wearing pants and short hair. In her text she also identified the participants as *two girls*.

Janice also marked the gender of the children in her journal entry describing their use of different apparatuses to move a heavy load (Figure 7.14). The class compared the ease of pushing and pulling a heavy bucket full of rocks, alternately using rolling sticks and a cart to move the load. Janice showed the different movement techniques in the first three quarter divisions of her journal entry. In the final quarter she drew the students she worked with on this project. She named those participants in an interview.

Lori: Do you remember who those people were?
Janice: That's me, and that's Katie, and that's Deborah (three girls in a row)
(Pause) That's Will (boy above and separated from girls).
Lori: Oh, and why are they all there on this one?
Janice: Because we were lifting that.

Janice drew the three girls including herself together in a row and placed the one boy Will some distance away from the girls. When describing the students in her interview, she listed the three girls first and then paused before giving Will's name. All of the students were wearing pants in Janice's drawing, but the girls and the boy were marked by differences in hair length. Boys in their journal drawing similarly marked the hair and sometimes clothing (boys in pants, girls in dresses) of students by gender.

Culture Theme

Although the students in these classrooms represented diverse cultural groups from around the world, explicit references to culture were surprisingly rare in their journal writing and drawing.

One example of a cultural reference is shown in He-Ping's journal (Figure 7.15). At the beginning of the year the classes studied how parts related to the whole of an object. For a number of different objects, Mrs. G and Mr. K asked students to respond to the following three questions. What is it? What does it do? How does it work? In He-Ping's entry about a clothespin, he addressed the first two questions in English and also in his native language of Chinese.

He-Ping had a good command of English but may have wanted to represent his ideas about science in his own language. Alternatively, he may have been translating the ideas from English to Chinese for another new Chinese student. Students familiar with the English language often acted as translators in oral and written discourse for other new students from the same home countries.

In another example, an African student Jill made a cultural reference to the United States rather than her home country (Figure 7.16). In the assignment students were asked to create their own inventions at the end of the year. Jill created and wrote about two inventions. Her second invention was a flag. She stated that a flag can be used to "present your country" and then gave as example, the United States' flag.

Other cultural references were found mainly in a solar system unit. One student discussed people living in different countries on the planet earth, and some students described an American astronaut landing on the moon.

Collaboration and Interaction Theme

Students showed themselves working together and with teachers conducting science investigations in their journal entries. They would sometimes draw the students who worked together with them in a small group during a science activity. In these entries, students often showed people talking together.

In one example, Preston drew a diagram of an experiment in which a balloon full of air connected to a string was let free and moved across the string (Figure 7.17). The teachers asked the students how the balloon moved. In Preston's diagram, he showed the students who had worked with him on this activity. Three people were gathered around the balloon, and one person observed the investigation from a distance.

A second example illustrates student collaboration in journal drawing. During a matter unit in which Mr. K and Mrs. G were emphasizing the concept that liquids take on the shape of their containers, Ellen collaboratively drew a diagram of a bottle and the shape of the liquid inside the bottle (Figure 7.18). In studying her entry, collaboration is not obvious. However, Ellen told me in an interview that the journal entry was a collaborative effort between Nimah and herself.

- Lori: When you did these journals, did you work on that alone (looking at a particular journal entry) or did you work with somebody else?
- Ellen: Alone.
- Lori: You worked on that alone. And do you always work alone, or sometimes do you work with other students on journals?
- Ellen: Sometimes we work with our tablemates. Sometimes we don't.
- Lori: And did you work with a tablemate on any of these pages?
- Ellen: (turns pages in journal and points to Figure 7.18) That one.
- Lori: Okay, so you worked with a tablemate. Do you remember who you worked with?
- Ellen: I worked with Nimah. She made this one (top object in Figure 7.18), and I made this one (bottom object in Figure 7.18).
- Lori: I see, and then did you both draw in her journal, too?
- Ellen: Mmhmm.
- Lori: Okay, and does it help to work with a tablemate on the journals?

Ellen: Yeah.
 Lori: How does that help?
 Ellen: Because it gets easier.
 Lori: I see, I see, and why is it easy?
 Ellen: Because it doesn't take a longer time to do work. It takes a longer time to do work by yourself, but if you work with somebody else, it's easier. It goes faster.
 Lori: That's a good idea.

Ellen explained how journal writing could be a collaborative and interactive effort with the advantages of ease and efficiency. Preston showed the collaboration of students in a science investigation that he later wrote about in his journal individually. Mrs. G and Mr. K encouraged both types of collaboration and interaction.

Flexible Student and Teacher Roles Theme

Students sometimes showed flexibility in the roles of students and teachers. Teachers and students were both represented as integral parts of the investigations, but neither was shown in positions of hierarchical control. Students and teachers worked together to actively investigate science phenomena.

In one journal entry, Sang-Ook showed how students worked together to lift one of their teachers with a lever and fulcrum assembly (Figure 7.19). He described how the students were active doers of the experiment while the teachers, Mr. K and Mrs. G, facilitated the students' actions.

Sang-Ook: (referring to Figure 7.19) This is Mr. K, and this is Fareed, this is me, and this is Foster trying to pull up Mr. K, but he was too heavy. Then we got a bowl of rocks, and then we put, Mrs. G. put a bunch of heavy rocks in, but it was too heavy. But when there was more sticks on my side, the bowl with the rocks went high. When we put more sticks on this side, Mr. K went up...
 Lori: It looks like Fareed is saying something in that picture?
 Sang-Ook: Yeah, he's laughing.
 Lori: Was it kind of funny to lift Mr. K?
 Sang-Ook: Yeah.

Sang-Ook's drawing of Fareed laughing suggests the comfort and ease he felt with the flexible roles of students and teachers in these experiments. Students enjoyed the role of Mr. K as an object in the experiment and their roles and ownership in making the experiment happen.

Jie similarly showed one of his teachers, Mr. K, as an active participant along with the students in a magnet fishing game (Figure 7.20). Mr. K, at the top of the picture, is fishing with magnets just like the students in the lower portion of the journal entry. At the bottom of the page, Jie wrote "so good to play" indicating his enjoyment of the activity and possibly his ease with the flexible student and teacher roles in the classroom.

Students saw themselves and their teachers in multiple roles in their science experiences. Students were often active participants in investigations of science phenomena showing ownership by drawing the *self and human elements* of themselves and other students in active positions and writing their ideas using the words *my* and *we*. The *flexible student and teacher roles* theme supports the student ownership shown in the *self and human elements* theme. Teachers would facilitate students' work but would also participate in the students' activities sometimes on an even basis.

Integration of Subjectivities, Language and Knowledge Themes

While one subjectivities theme was highlighted in each of the above examples, many journal entries including the above examples contained multiple subjective themes along with themes about language and knowledge. The following entries give examples of how the themes of subjectivities, language and knowledge were integrated in students' journals.

Janine drew a picture and wrote about a science activity in which the class put a known amount of water through a funnel filled with soil and then measured the water

which filtered through (Figure 7.21). The class did this investigation to show that soil holds water. In her diagram Janine drew many students and teachers at work. Her entry contained many subjective themes. She included her *self* and other *people* in the diagram and wrote a sentence beginning with *I*. In this sentence, she shared her *emotions* about science stating, “*I like science.*” She illustrated *collaboration and interaction* among the participants. Students were shown working together at tables with the teachers. In her writing she expressed collaboration by stating, “*We do science today.*” *Gender* was also clearly marked in her diagram. All of the students were girls wearing dresses with long hair and hair ribbons. Janine confirmed these collaboration and gender themes in an interview.

- Lori: When I was looking at your journal, I saw all of these people (Figure 7.21). Can you tell me about all of these people that you’ve drawn?
- Janine: ...I draw different people.
- Lori: You’re showing the people are doing experiments? (Janine nods yes.) I see there are two people. Is it two girls at every table?
- Janine: Yes.
- Lori: Are those two working together at that table?
- Janine: Yes. (Points to single girl at table) She is by herself.

Janine also portrayed in her journal and discussed in an interview the importance of *conversation* in her science experience.

- Lori: On this page (Figure 7.21), I was wondering, I see some lines coming out of the people’s mouths. What are those lines?
- Janine: This, the lines?
- Lori: The little lines that come out of the mouths.
- Janine: Talking. (I asked if talking was important, and Janine nodded yes, but then told me that when she first came to this school, she did not know much English. She then directed me to later parts of her journal where she did more writing than drawing when she knew English much better.)

Along with the language theme of conversation, Janine showed *active definitions of science knowledge*. She described the science investigation in an active form in her text, “*We do science today.*”

Janine used all of the themes, subjectivities, language and knowledge, to fully represent her science experience. She made detailed drawings of *students* with *gender markings* (subjectivities theme) *actively involved* (knowledge theme) and *talking* (language theme) about the soil absorption activity. Her accompanying text expressed *emotion* (subjectivities theme) and *action* (knowledge theme) in science.

Similarly, Joey expressed themes of subjectivities, language and knowledge in his journal. When writing about the lever and fulcrum activity in which the students lifted their teacher, Joey drew many students working together with their teacher, Mr. K (Figure 7.22). The students had active roles lifting the load, their teacher, which demonstrated the subjective theme, *flexibility of roles between students and teachers*. *Collaboration and interaction* were also seen as the students worked together to lift the load. Mr. K is *gender marked*, as a man with short hair as is the boy student saying “Yes” next to him. The other two students saying “No” and “Yes” may be girls as their hair is longer, but the distinction is not completely clear.

Conversation was again an important language theme as Joey showed the students and Mr. K talking together along with an onlooker saying, “Go, go.” Joey discussed the dialogue balloons and collaboration of the students in an interview.

Lori: Is this Mr. K (Figure 7.22)? Why is he saying, “Stop”?
Joey: He said, “Stop” because, I forgot why he did say, “Stop,” but he did say, “Stop.”
Lori: He did say, “Stop.” And then were these, some of the students?
Joey: Yeah.
Lori: And why were they saying, “Yes,” and one said, “No.”
Joey: I forgot.
Lori: And who’s this one over here saying, “Go, go”?
Joey: Oh, yeah, we were sitting on a chair saying, “Go, go, try and hold Mr. K up.”
Lori: So, some of the kids were working to lift him up, and some were watching on the chair saying, “Go, go.”
Joey: Mmhmm.

Lori: Can you tell me, Joey, why you put the people in here, and why you put what they said in your journal? Why was that important? (No response from Joey.)

In the interview Joey acknowledged the conversation and collaboration of the students and teacher in the science activity.

Like Janine, Joey also saw science as an *active form of knowledge* by showing all of the *students* (subjectivities theme) working together to lift the load (knowledge theme). *Conversation* (language theme) was essential to making the science happen as the students and Mr. K together verbally directed their actions to lift the load. In addition, Joey gave a more traditional knowledge form, a *symbolic representation* of the activity (more like conventional science diagrams). In his symbolic diagram at the bottom of the journal, he labeled the “load” and “level” on the fulcrum and drew arrows showing the direction of movement. However, he placed the symbolic representation along with the diagram of people working and talking about science together. He integrated subjectivities, language and knowledge to convey the complete meaning of his science experience.

In another example, Kamila wrote an extensive story and prepared an accompanying storyboard drawing about her design and testing of a toy boat (Figure 7.23). After doing much work determining the floating or sinking and absorption characteristics of a variety of materials, teachers asked students to bring this knowledge to bear on designing a toy boat that could both float and carry a load of marbles. Students had the opportunity to revise their plans and prepare a second boat improving the floating and/or load carrying potential based on the results of testing their first boat design in a tub of water. Kamila made many references to herself and a friend Sarah in both her writing and drawing illustrating the subjective, *self and human elements* theme. She began by

referencing herself in the title of her writing, “*My Story about My Boat*”. Throughout the story Kamila included herself using the terms, *my* and *I*, and referenced her friend Sarah by name. Use of the word *my* indicated that Kamila felt ownership of this science activity, the creation of a boat. The *self and human elements* theme was also present in the storyboard drawing following Kamila’s text story. In the first panel of the storyboard (Figure 7.23d), Kamila drew a hand assembling the boat. In the remaining panels, she drew herself conducting the boat testing and included a drawing of her friend Sarah in the third panel.

There are some indications of the *emotions* theme in Kamila’s portrayal of her interaction with Sarah. In her story, Kamila wrote that Sarah pushed the boat making it wet and then added in parentheses, “she did not mean to do it!” (Figure 7.23c). Likewise, in the third panel of the storyboard (Figure 7.23d), there is a dialogue balloon from Sarah saying, “Sorry!” Kamila’s use of the exclamation points helped to convey the disappointed emotions she and Sarah felt when Sarah accidentally pushed Kamila’s boat. In the last panel of the storyboard (Figure 7.23e), Kamila expressed her triumph in designing a second boat that did float. She stated, “I told you it would float!” Kamila appeared to express a feeling of delight with the exclamation of her success floating the second boat.

The *gender* of the two girls is clearly indicated with the naming of Sarah in Kamila’s story and the drawing of each girl with long hair and Kamila sometimes wearing her hair in a ponytail in the storyboard.

Another subjectivities theme, *collaboration and interaction*, was expressed in most student journals by positive messages of students working together in helpful ways on science activities. This example is different in that Sarah’s interaction produced a

negative result, the ruin of Kamila's first boat. Instead of being upset by the experience, however, Kamila understood Sarah's intervention as an accident and used the interaction as an opportunity to create a second, revised boat. This interchange demonstrates the close sense of community felt by the students in the classroom.

Language themes included both a text *story* and *conversation*. The use of story (or narrative) elements was previously documented in students' oral science circle conversations. Occasionally, students also wrote stories in their science journals as Kamila did here. While Kamila's story and accompanying drawing of a boat give a detailed account of this science activity, she further elaborated her journal entry with the storyboard including *conversation* through the dialogue balloons of Sarah and herself. Neither story or conversation are traditional elements of written scientific reports. Encouraged by Mrs. G and Mr. K to use a wide variety of language forms, Kamila may have found story and conversation to be the best or perhaps most creative ways to represent this science experience. Like others who explicitly portrayed *conversation* in their journals, Kamila may have wished to show the conversational nature of her science activities or may have considered conversation an essential component of her science work. The above-described *subjectivities* themes are interwoven throughout Kamila's story and in the conversation depicted in the storyboard. These nontraditional venues of communicating about science may have allowed Kamila to more completely express the subjectivities of self and human elements, gender, emotions and collaboration and interaction.

In addition, Kamila clearly represented her understanding of the science knowledge required to design a boat that could float. Like others, Kamila expressed an *active form of knowledge*. She (her subjective *self*) *actively constructed* a boat conveying

the knowledge act through both story and conversation (language). Kamila also displayed a somewhat more conventional form of science knowledge. Following her story, she made an annotated drawing of her boat (Figure 7.23c). Each part of her boat was labeled, and she placed various annotations in balloons around the boat explaining the function of each part. One of the annotations emphasized an *active form of knowledge*. She stated the function of the feather as “so I can blow on it and it would move”. She described herself (*I*) in that annotation as the *actor* on the boat linking *subjectivities* with *knowledge*. Other students similarly showed subjectivities, language and knowledge integrated together in their journal writing and drawing.

Journals Situated within Classroom Discourse

The *conversation* and *collaboration and interaction* themes were found throughout the student journals indicating that conversation, collaboration and interaction were important components of their scientific experiences in talk and writing. The presence of *conversation, collaboration and interaction* elements in students’ journal writing shows that the classroom emphasis on these discourse features crossed over to journal writing from whole class conversations. At the same time some students used journals to a much greater extent than they used classroom oral discourse. Most beginning English users had low levels of spoken and written discourse. Mr. K and Mrs. G encouraged beginning English users to draw pictures of their science experiments along with writing short phrases. As students gained familiarity with English, many intermediate English users increased their levels of written discourse prior to spoken conversation. The varied use by students of journals and conversation indicates the importance of using both written and spoken discourse in science. The personal,

subjective elements expressed in the journals may represent a high comfort level by some students with this discourse form.

Summary

I analyzed students' science journals for the presence of subjectivities, personal and social observations and characteristics. These personal expressions were found in the majority of students' journal entries, and there were some trends in their overall expression. Girls expressed subjectivities themes in their journals more often than boys, and all students expressed subjectivities themes more for life science topics than for physical science topics. Both of these patterns may be connected. Typical socialization expectations suggest that girls are more likely to express themselves personally than boys and that people feel more personally connected to life science than physical science. The differences were not extensive, however, as subjectivities themes were present in the majority of both boys' and physical science journal entries. The presence of subjectivities themes also increased over the school year possibly indicating the support of the classroom community for this kind of writing and drawing or students' increased personal engagement with science.

Specific subjectivities themes found in the student journals included *self and human elements, thinking, emotions, gender marking, culture, collaboration and interaction* and *flexible student and teacher roles*. By far, the most common theme was *self and human elements*. Secondly, students expressed the theme of *emotions* in their journals followed by *thinking, gender* and *collaboration and interaction* all to a similar degree. Only a small number of references were found for the *culture* and *flexible student and teacher roles* themes. Few differences were found in the specific subjectivities themes by gender, topic or time.

Students expressed many language and knowledge themes in addition to subjectivities in their journal writing and drawing. A predominant language theme was *conversation* as students sometimes drew themselves talking with other students through the use of dialogue balloons. A key knowledge theme was *active forms of knowledge*. Students often portrayed themselves and others actively involved in science experiments. Overall, students presented rich, detailed portraits of their science experiences both expressing and integrating subjectivities, language and knowledge themes. Students made drawings of themselves and other students (subjective theme) talking together (language theme) as they actively worked (knowledge theme) on a scientific investigation.

The journal writing and drawing provided a complementary form of discourse to the circle conversations analyzed earlier. The subjective, *collaboration and interaction* theme and the language theme of *conversation* were present in both oral and written discourse demonstrating the overlap of features and continuity between these discourse forms in the classrooms. Different students used conversation and writing to varying degrees. The wide range of freedom in both discourse forms allowed students to fully represent and communicate their science experiences (Hanrahan, 1999; Klein, 2000; Rath & Brown, 1996; Rowell, 1997).

Discussion

The rich, holistic student journal writing and drawing exhibited in these classrooms in many ways *expanded* the discourse through students' personal expressions and integration of these subjectivities with knowledge and language. The teachers, Mrs. G and Mr. K, encouraged students to fully express themselves in their science writing and drawing. Students used a variety of nontraditional and traditional forms to represent and

communicate their science experiences integrating subjectivities, language and knowledge.

When interviewed, students described many of the subjectivities, language and knowledge themes as important to their work. When specifically asked about *subjectivities* themes, students explained their necessity and saw them as integral to their journal entries. The students' subjective expressions may represent a more personal, connected way of interacting with science. Bronwyn Davies (1993) explains that subjectivities are achieved through our own relationships with others and through discourse.

The processes through which subjectivities are constituted are imbricated, not only in ways of speaking and ways of making meaning, but also in the contexts and relations in which particular acts of speaking take place. Unlike identity, subjectivity is not a semi-fixed essence (as the concept of socialisation within humanist theory suggests) but is constantly achieved through relations with others (both real and imagined) which are themselves made possible through discourse. (p. 9-10)

The strong presence of subjectivities themes including collaboration and interaction along with conversation demonstrated these shaping factors in the students' journal writing and drawing. As adults we can begin to relearn from these students how to acknowledge and integrate our subjectivities in science.

In a few ways, however, the discourse may have been *constrained* in the students' science journal writing and drawing. There was a somewhat greater presence of *subjectivities* themes in girls' journals and in life science topics. Girls are often considered to be more personally expressive than boys. While the difference between the girls' and boys' expressions of subjectivities is not large in this analysis, it may signify the beginning of a trend that could become more pronounced over time. Similarly, life science topics are considered to be more open to personal expression than physical

science topics. Fortunately, the small differences at this grade level could be overcome with more encouragement of personal expression in science for all topics by both girls and boys.

Bruno Latour (1993) and Ruth Hubbard (1989) contribute to this discussion by alerting us to the dangers of limiting our conceptions of science to traditional views of an abstract, objective enterprise removed from human influence. They explain in a broader context the importance of *subjectivities* in science. They clarify how science has become separated from its social context and call for a broader, humanistic, *subjective* understanding of science similar to the portrayals of science in these students' journals.

Separation of Nature and Culture

Bruno Latour (1991) illustrates how modern Western society is by definition separated into disciplinary divisions. He gives as example the everyday activity of reading the newspaper. Newsworthy subjects are typically broken down into their respective formal categories. For example, when reading about the AIDS virus, "the analysts, thinkers, journalists and decision-makers will slice the delicate network traced by the virus for you into tidy compartments where you will find only science, only economy, only social phenomena, only local news, only sentiment, only sex" (p. 2).

If we rebel against this clean separation of a complicated topic into bounded categories and see connections across categories or even a messier, complex picture not easily divisible, analysts help us to redefine and simplify our thinking. They remind us that "on the left, they have put knowledge of things; on the right, power and human politics" (p. 3).

Specifically, Latour states that we separate knowledge, society and language. If we attempt to interweave them, they become incomprehensible.

Our intellectual life is out of kilter. Epistemology, the social sciences, the sciences of texts - all have their privileged vantage point, provided that they remain separate. If the creatures we are pursuing cross all three spaces, we are no longer understood (p. 5).

However, when we carefully examine these children's writing and drawing, we see that they have not made such clear distinctions between knowledge, language and the social or subjectivities like adults might. They view their world in a holistic manner meaningfully expressing and integrating subjectivities, knowledge and language in their work.

The Social Context of Science

Like Latour, Ruth Hubbard (1989) illuminates and challenges our conventional understandings of science. She states that "making facts is a social enterprise" (p.119). Individuals do not go off on their own and create facts. These facts must be in agreement with what others think, or people might be forced to agree. In any case, it is a "human enterprise." As a human enterprise, the doers of science, the scientific community, then shape science.

Like many feminists Hubbard calls into question the basic principles of objectivity from which scientists operate. Their definitions of objectivity serve to keep those possessing power in power and to deny others access to science. In traditional science, scientists are objective by supposedly separating themselves from their objects of study. This goal is represented in scientific writing which deletes the scientist as agent in the report. Hubbard states that instead we must completely acknowledge our role and location in the process of science.

Awareness of our subjectivity and context must be part of doing science because there is no way we can eliminate them. We come to the objects we study with our particular personal and social backgrounds and with inevitable interests. Once we acknowledge those, we can try to

understand the world, so to speak, from inside instead of pretending to be objective outsiders looking in (p. 127).

Making our subjectivity and context explicit are beginning steps to Ruth Hubbard's summons for a broader science that is inclusive to the voices that have not been recognized previously. Again, we can learn from the work of these elementary students who see their subjectivities as inextricably linked to their science learning. They with the help of their teachers give us a vision of science that is broader, more inclusive and recognizes its human quality.

The Importance of Subjectivities in Science

In contrast to traditional views of science as impersonal, emotionless, value free truth, these students expressed views of science that were human, conversational, connected, emotional and contextual. Students' integration of their subjective experiences along with human language and traditional scientific principles of knowledge may be helpful in more broadly envisioning a more humane, holistic science. Latour (1993) describes the process by which we have divided human culture from nature which is not human (science). Hubbard (1989) asks us to recognize our human involvement and the broader social context of science.

In their science journals and conversations, these students naturally integrated human culture and non-human nature. Mr. K and Mrs. G intentionally encouraged students' full expression of their science experiences. Perhaps we can learn from them ways to reintegrate science and culture for our students and ourselves.

Many researchers (Davies, 1989, 1993; Hazelwood, 1996; McLaughlin & Heath, 1993; New London Group, 1996), in addition to Kathleen Weiler (1988; 1999), have been calling our attention to the importance of *subjectivities* and the intertwined concepts of

positions and identities in education. The high levels of *subjectivities* shown by students in these journals indicate the importance of personal expression to their complete understanding of science. A greater emphasis on *subjectivities* in science education may help more students to connect and experience science in meaningful, personal ways.

Table 7.1 – Profiles of Students

Student Name	Gender	Cultural Back-ground	Level of Written Discourse	Level of Oral Discourse	English Language Use
Boseda	boy	African	low	moderate	intermediate
Ellen	girl	African	low	moderate	high
Evan	boy	Asian	moderate	high	high
He-Ping	boy	Asian	high	high	high
Hyun-Shik	boy	Asian	high	high	high
Jae-Hwa	girl	Asian	moderate	low	intermediate
Janice	girl	African American	high	low	native
Janine	girl	Asian	moderate	low	intermediate
Jie	boy	Asian	low	low	beginning
Jill	girl	African	high	high	high
Joey	boy	Asian	moderate	low	intermediate
Kamila	girl	European	high	high	high
Kirk	boy	European American	low	moderate	native
Mariana	girl	Latin American	low	moderate	intermediate
Natalie	girl	European American	high	high	native
Preston	boy	Asian	high	high	high
Rati	girl	Asian	moderate	low	intermediate
Rebecca	girl	Asian	high	high	high
Sang-Ook	boy	Asian	moderate	high	high
Xiaoping	boy	Asian	low	low	beginning

Table 7.3 – Trends in Specific Subjectivities Themes

Category	Subjectivities Themes						Total Number of Themes
	Self and Human Elements	Thinking	Emotions	Gender Marking	Culture	Collaboration and Interaction	
All Journals	272 ^a (47) ^b	69 (12)	86 (15)	67 (12)	7 (1)	60 (10)	577 (100)
Gender							
Girls	161 (45)	45 (12.5)	57 (16)	47 (13)	2 (0.5)	35 (10)	358 (100)
Boys	111 (51)	24 (11)	29 (13.2)	20 (9)	5 (2.2)	25 (11.4)	219 (100)
Topic							
Life Science	88 (64)	28 (20.5)	8 (6)	6 (4.5)	0 (0)	7 (5)	137 (100)
Physical Science	184 (42)	41 (9)	78 (18)	61 (14)	7 (1.5)	53 (12)	440 (100)
Time of Year							
Beginning	141 (46)	17 (5)	52 (17)	45 (14)	2 (1)	36 (12)	309 (100)
Middle	56 (56)	22 (22)	7 (7)	4 (4)	3 (3)	8 (8)	100 (100)
End	75 (44.5)	30 (18)	27 (16)	18 (11)	2 (1)	16 (9.5)	168 (100)

Codes:

^aNumber of journal entries

^bPercentage of specific themes (in parentheses and italics)

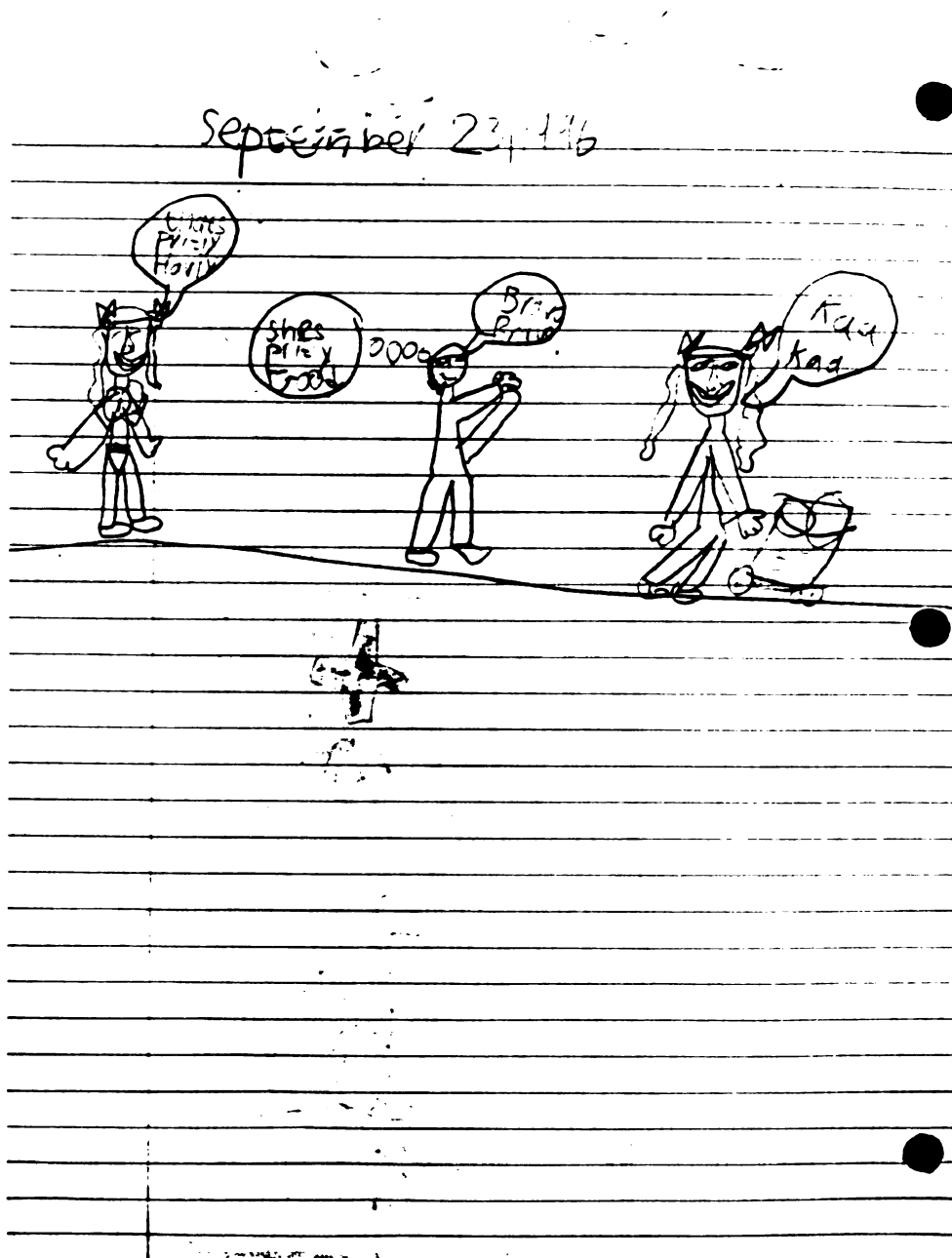


Figure 7.1 - Example Entry from Mariana's Journal

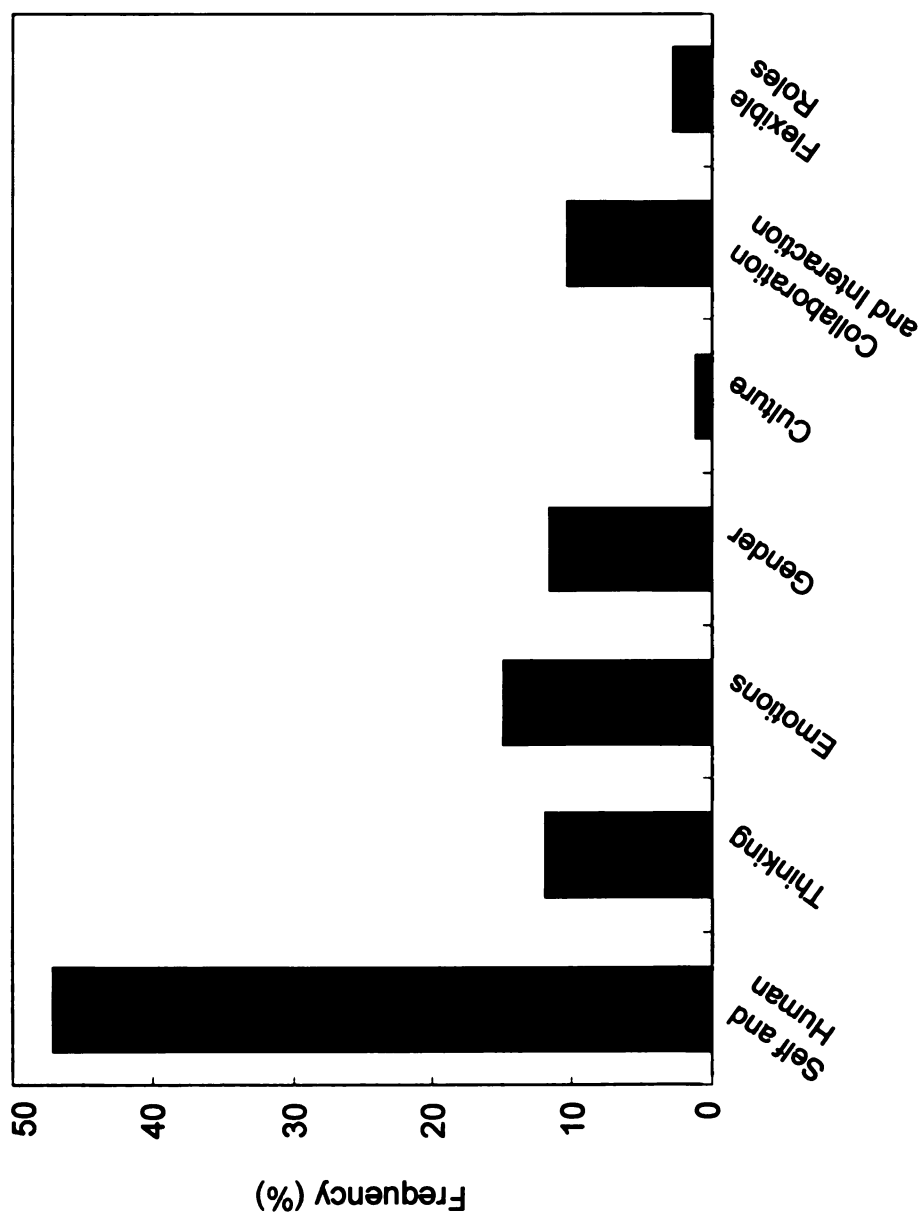


Figure 7.3 - Frequency of Subjectivities Themes in Student Journals

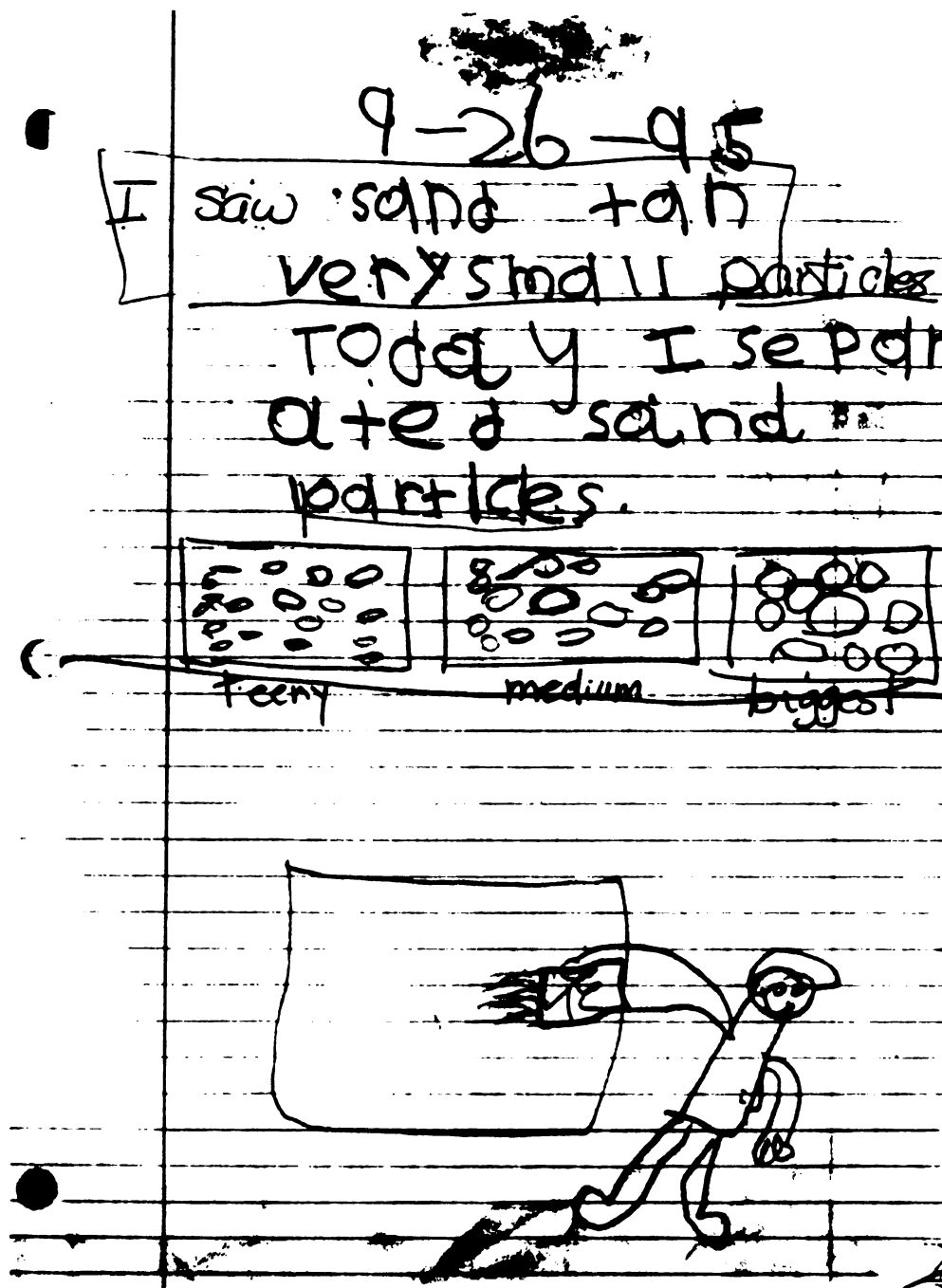


Figure 7.4 - Example of "Self and Human" Theme in Boseda's Journal

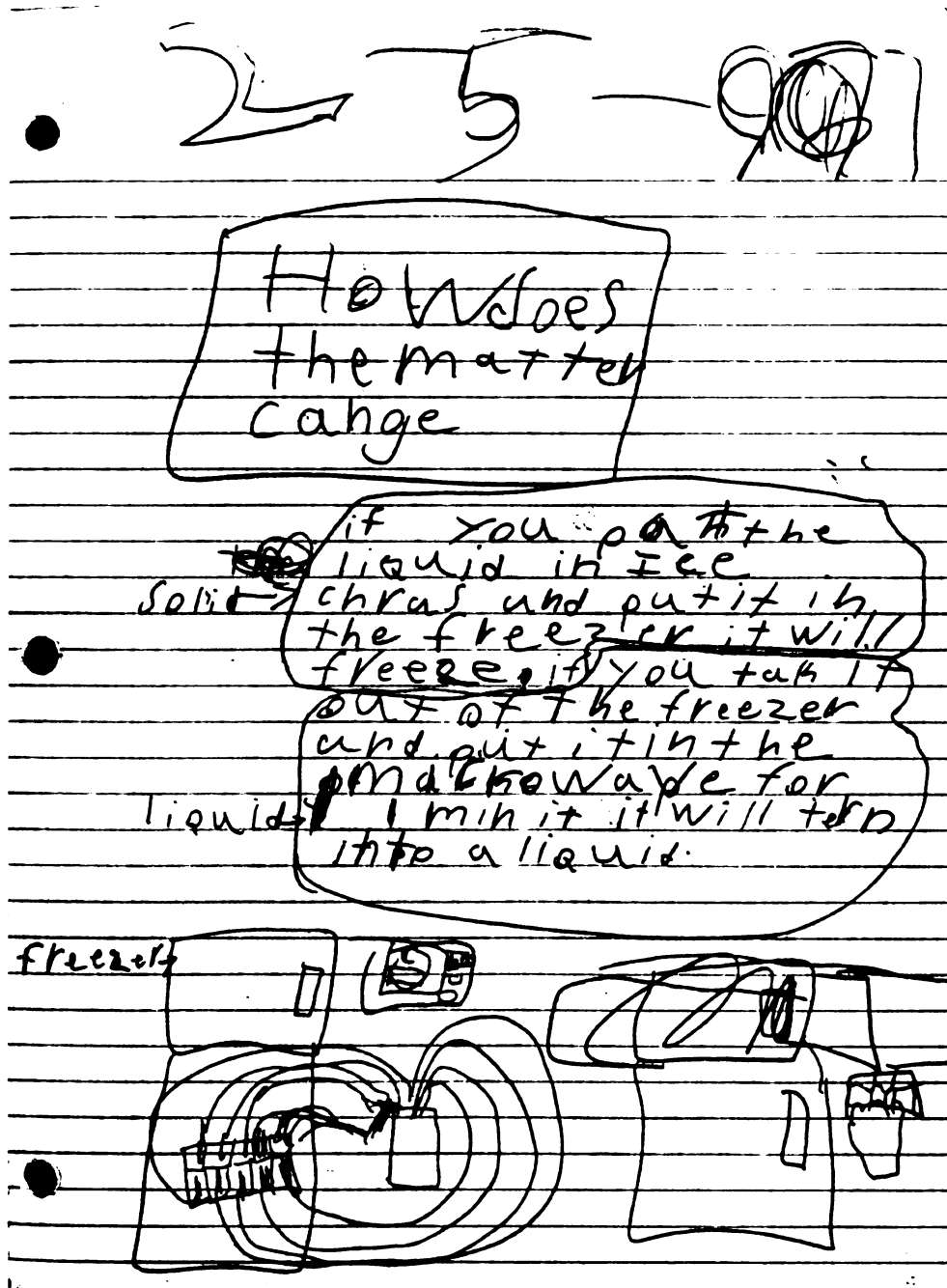


Figure 7.5 - Example of "Self and Human" Theme in Natalie's Journal

7-23-96

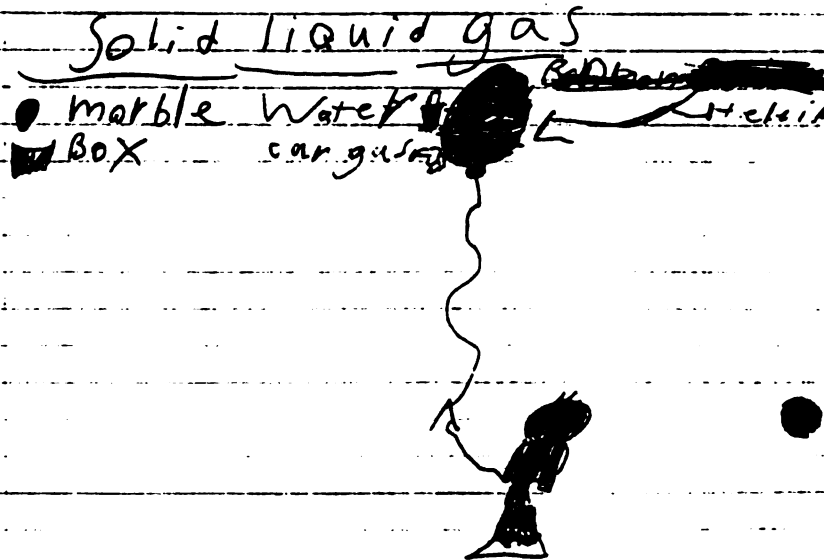


Figure 7.6 - Second Example of "Self and Human" Theme in Natalie's Journal

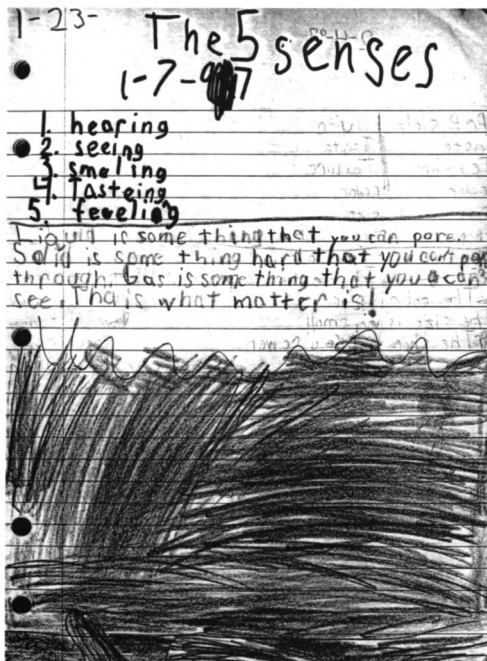


Figure 7.7 - Counter Example of "Self and Human" Theme
in Kirk's Journal

5-22-96

I Learned That toads walk
and frogs hop. I Learned that one frog
can kill one thousand people. Some frogs
live in fire. I Learned that
toads are more poison than frogs.
Some frogs live in ice.

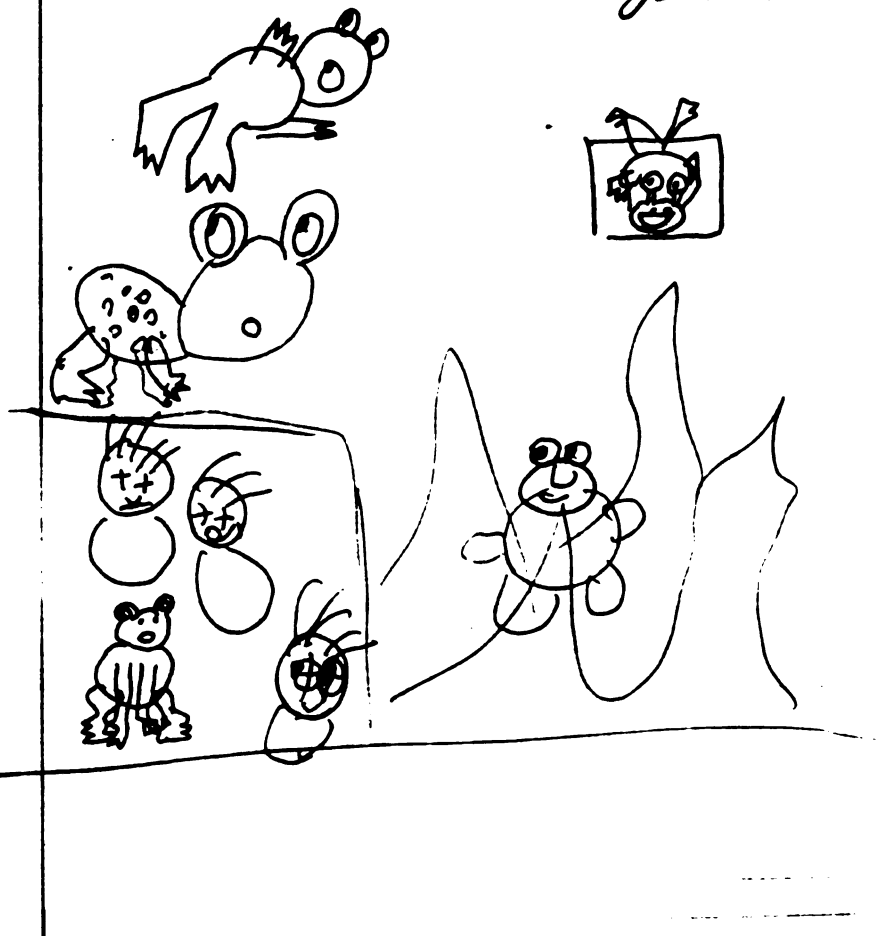


Figure 7.8 - Example of "Thinking" Theme in Evan's Journal

2 ~ 2 | Nov 16
I ~~know~~ know that oranges
have ring.
I forget I did not
no that and
MR K [redacted] Oske
d somebody
and I read
ber
v
guy

Figure 7.9 - Example of "Thinking" Theme in Rati's Journal

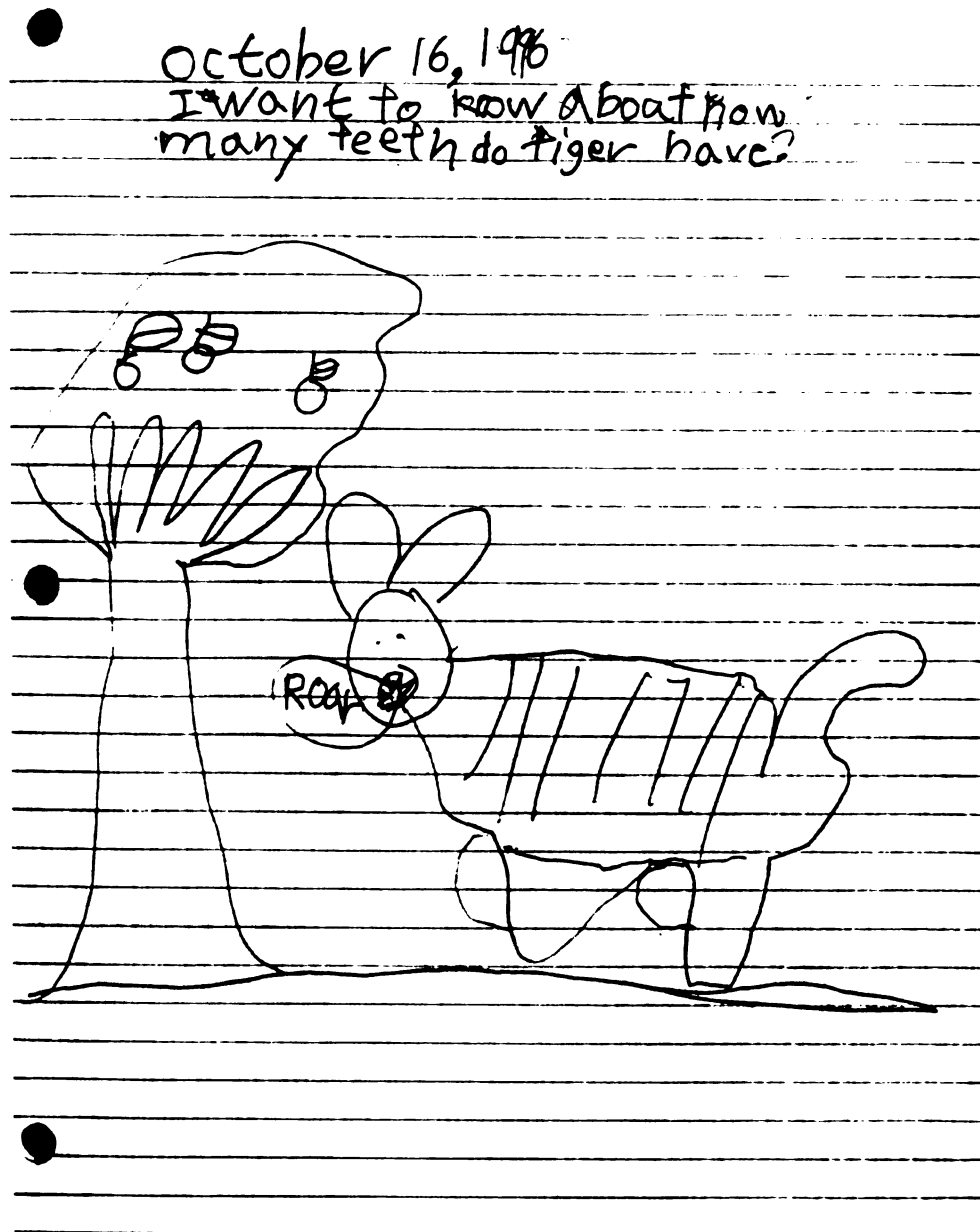


Figure 7.10 - Example of "Thinking" Theme in Xiaoping's Journal

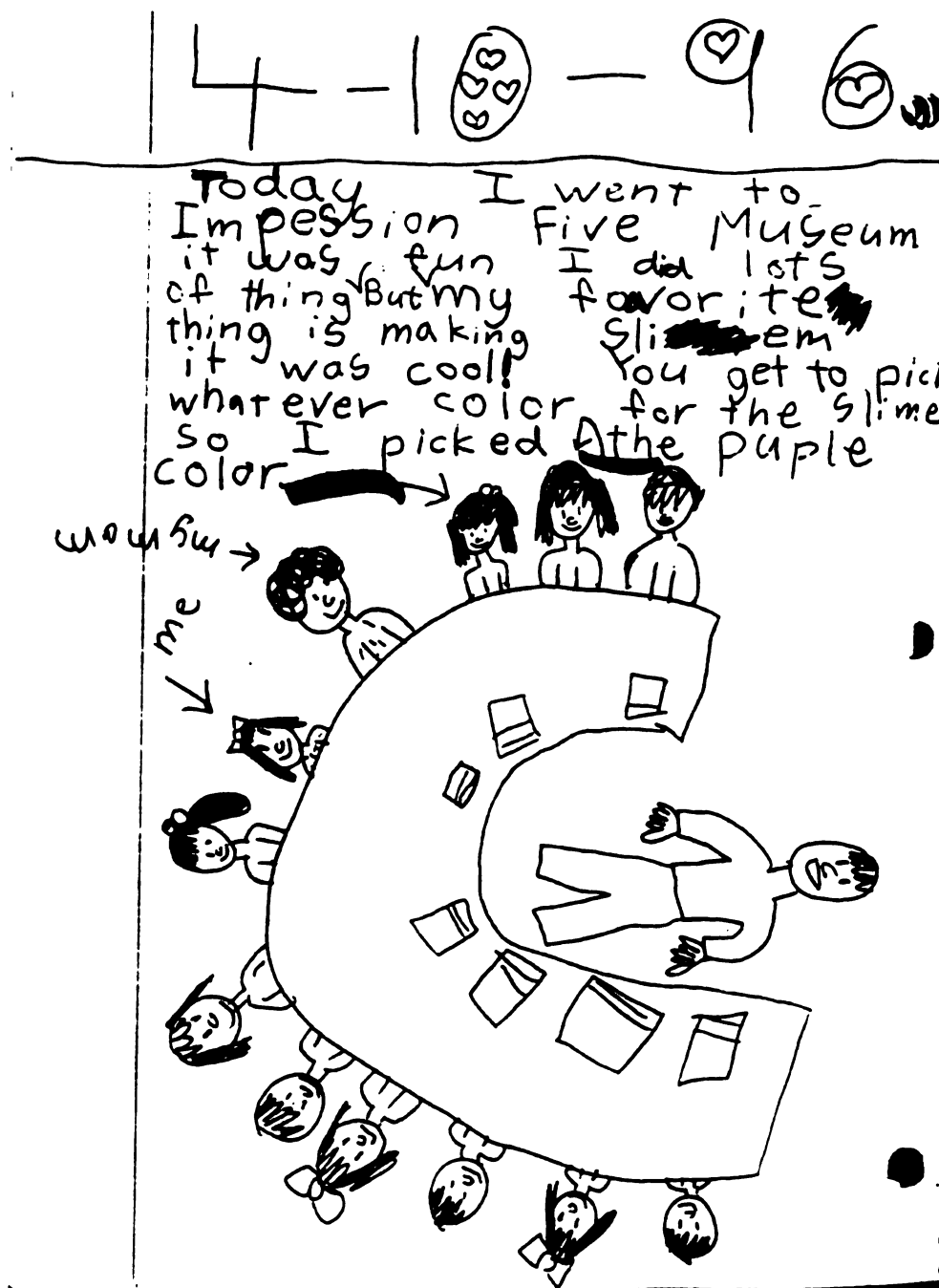


Figure 7.11 - Example of "Emotions" Theme in Jae-Hwa's Journal

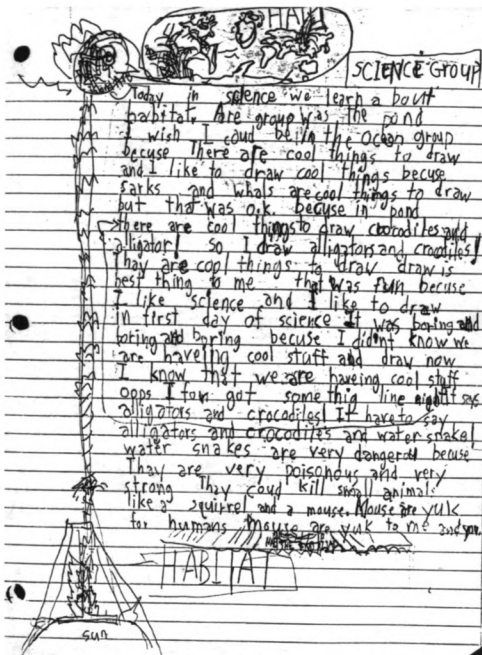


Figure 7.12 - Example of “Emotions” Theme in Hyun-Shik’s Journal

10-2-96

This is two girls swinging.
The rope is ~~moving~~ also
moving. The rope is also
helping the two girls move.

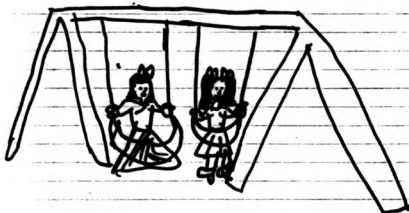


Figure 7.13 - Example of "Gender" Theme in Rebecca's Journal

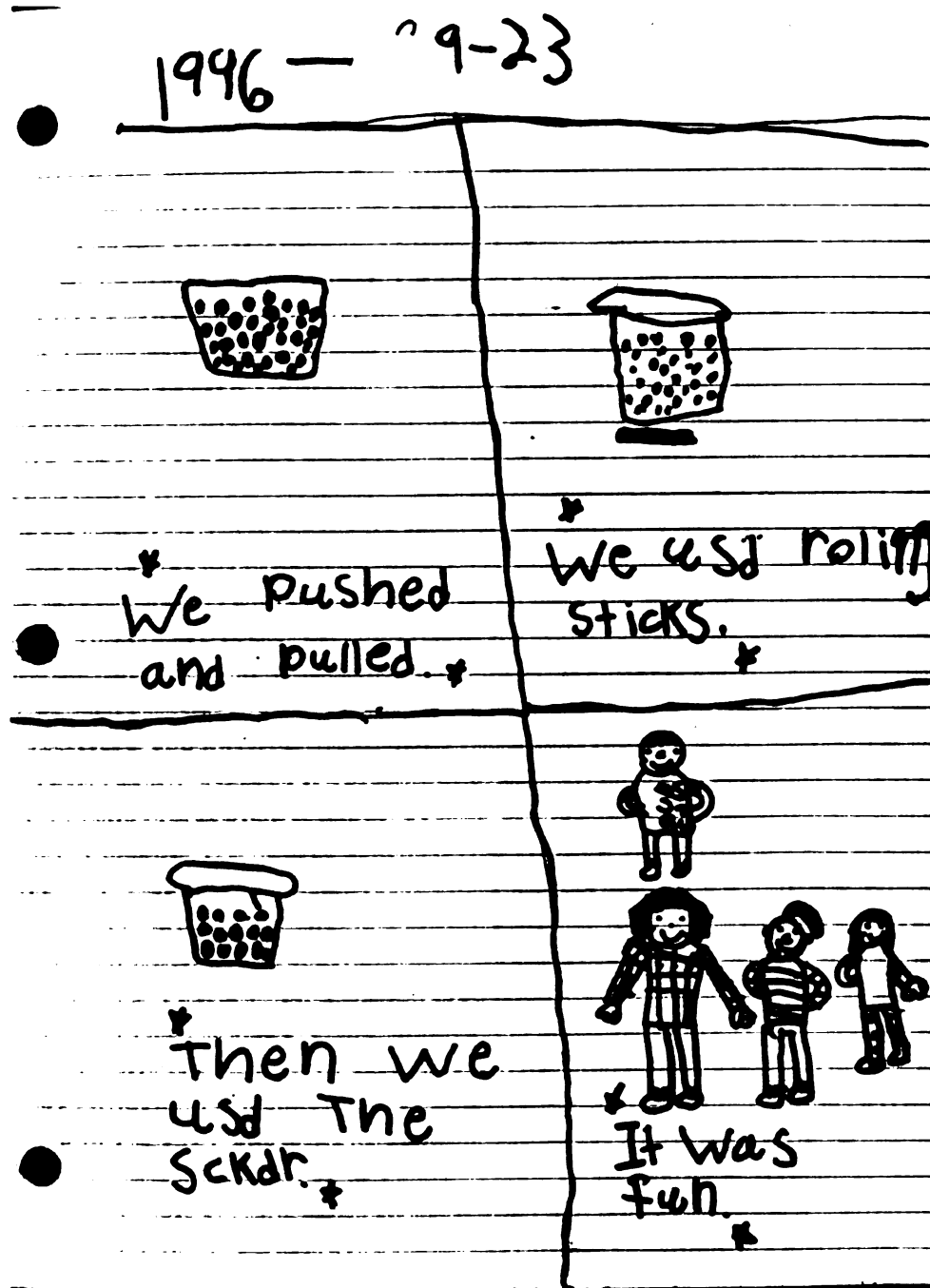


Figure 7.14 - Example of "Gender" Theme in Janice's Journal

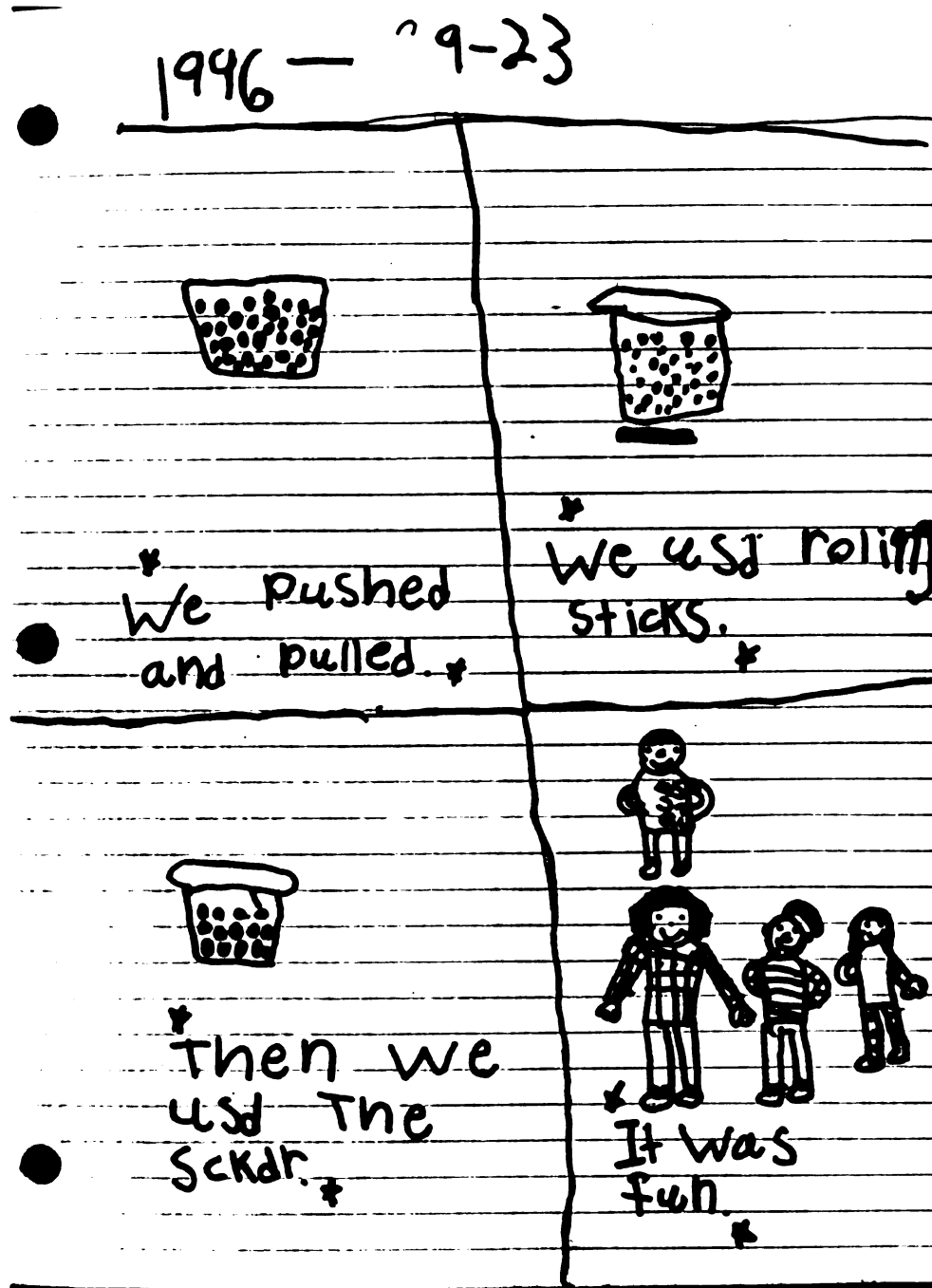


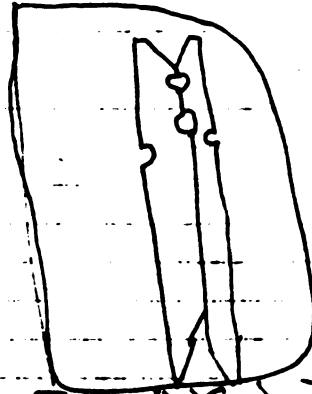
Figure 7.14 - Example of "Gender" Theme in Janice's Journal

*这是什么?

① What is it?

什么是 jia zi!

*It is a clothespin.



② 这是什么?

What does it do?

It can clip
paper.

Figure 7.15 - Example of "Culture" Theme in He-Ping's Journal

Same Day
I made a other Invention
it is a flag. ~~use~~ you
use ~~it~~ it to presents
you Contury. Like the
u.s.a. flag.



Figure 7.16 - Example of "Culture" Theme in Jill's Journal

9-16-96

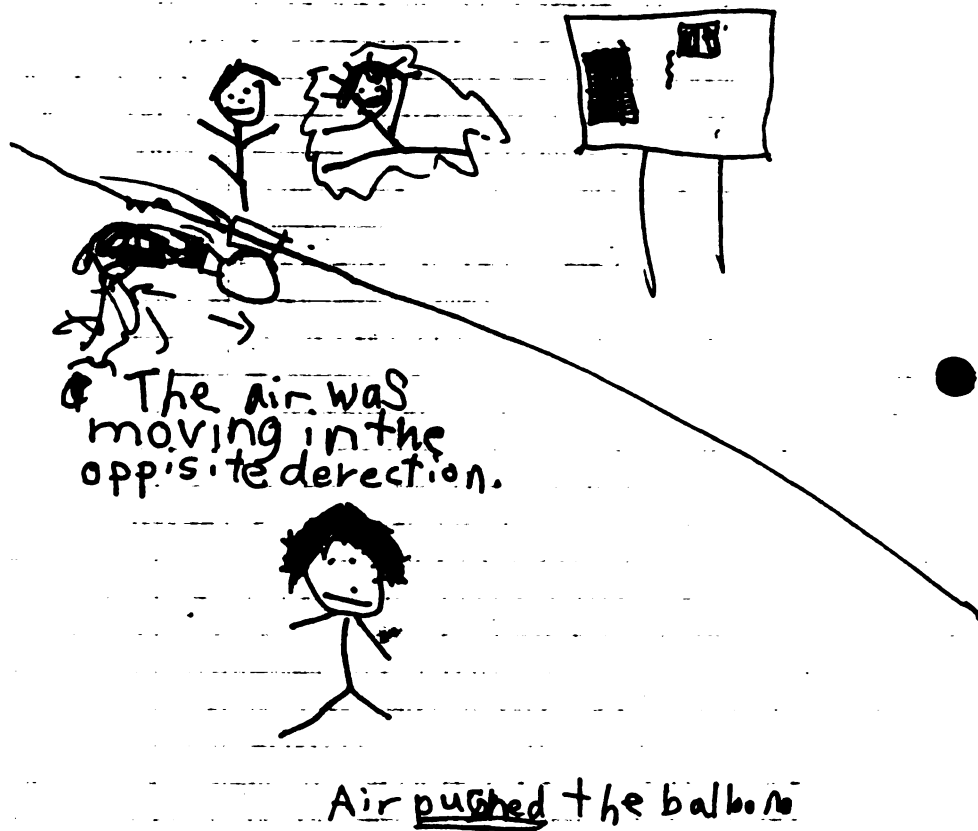


Figure 7.17 - Example of "Collaboration and Interaction"
Theme in Preston's Journal

3-11-96



Figure 7.18 - Example of "Collaboration and Interaction"
Theme in Ellen's Journal



Figure

September 26, 1996

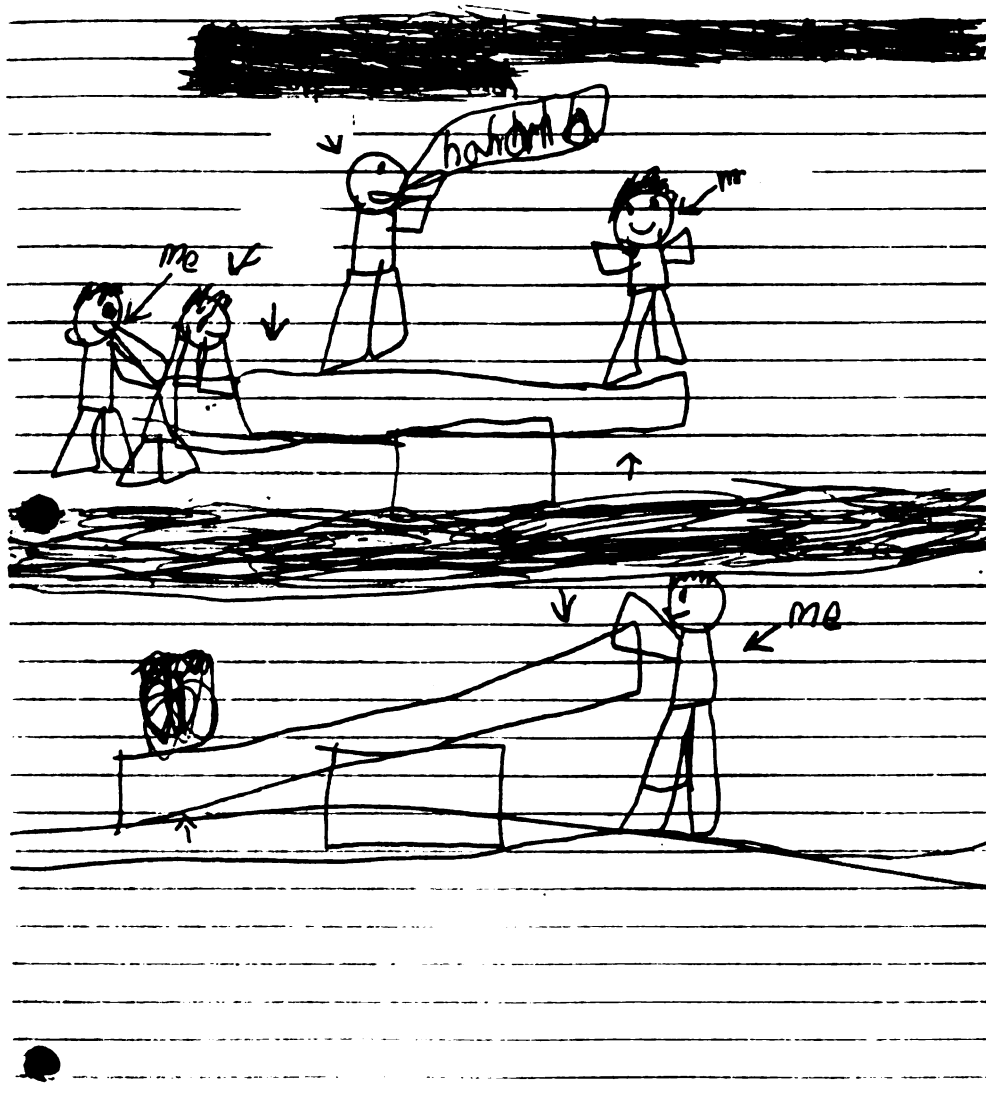


Figure 7.19 - Example of "Flexible Student and Teacher Roles" Theme in Sang-Ook's Journal

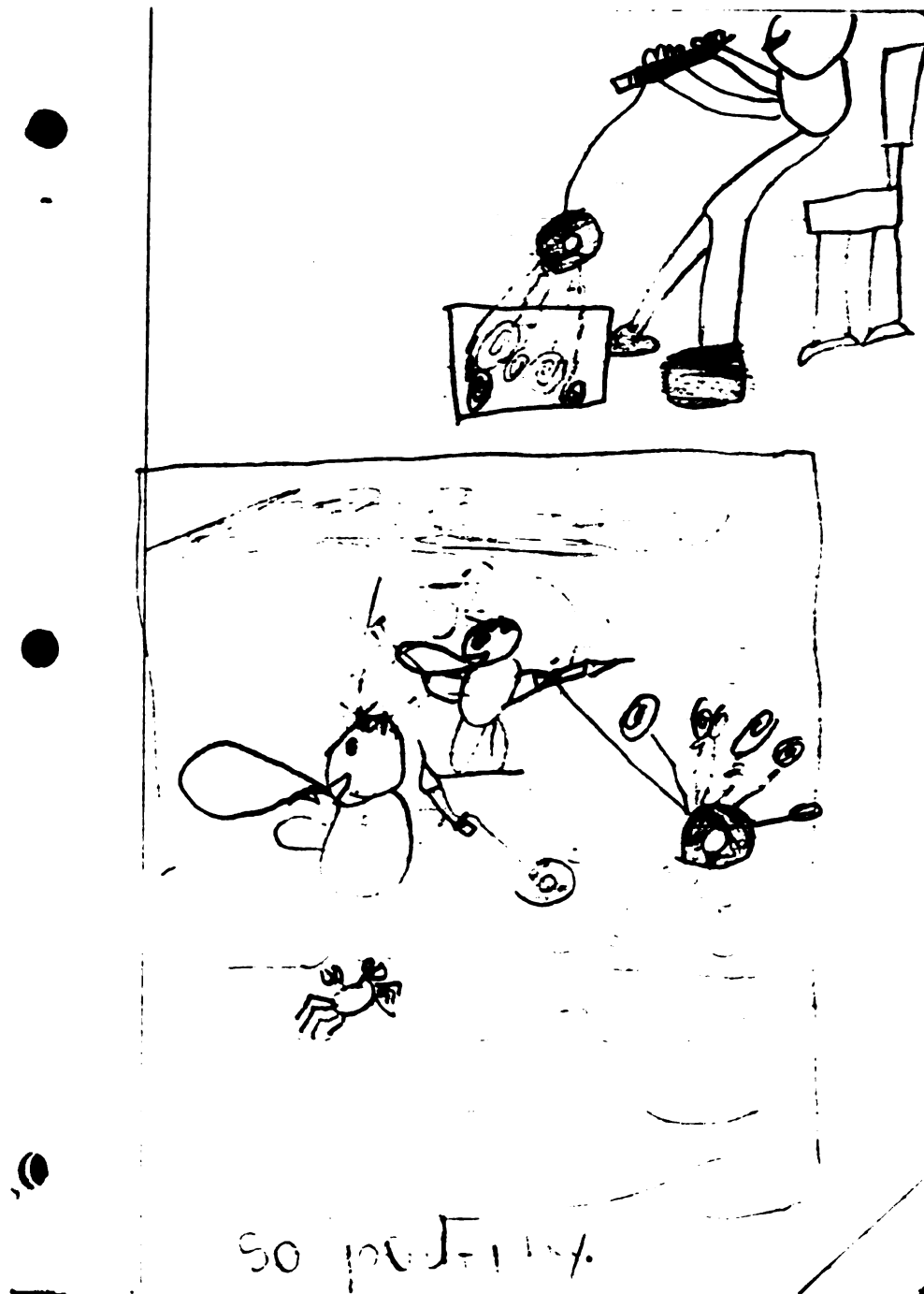


Figure 7.20 - Example of "Flexible Student and Teacher Roles"
Theme in Jie's Journal



Fig

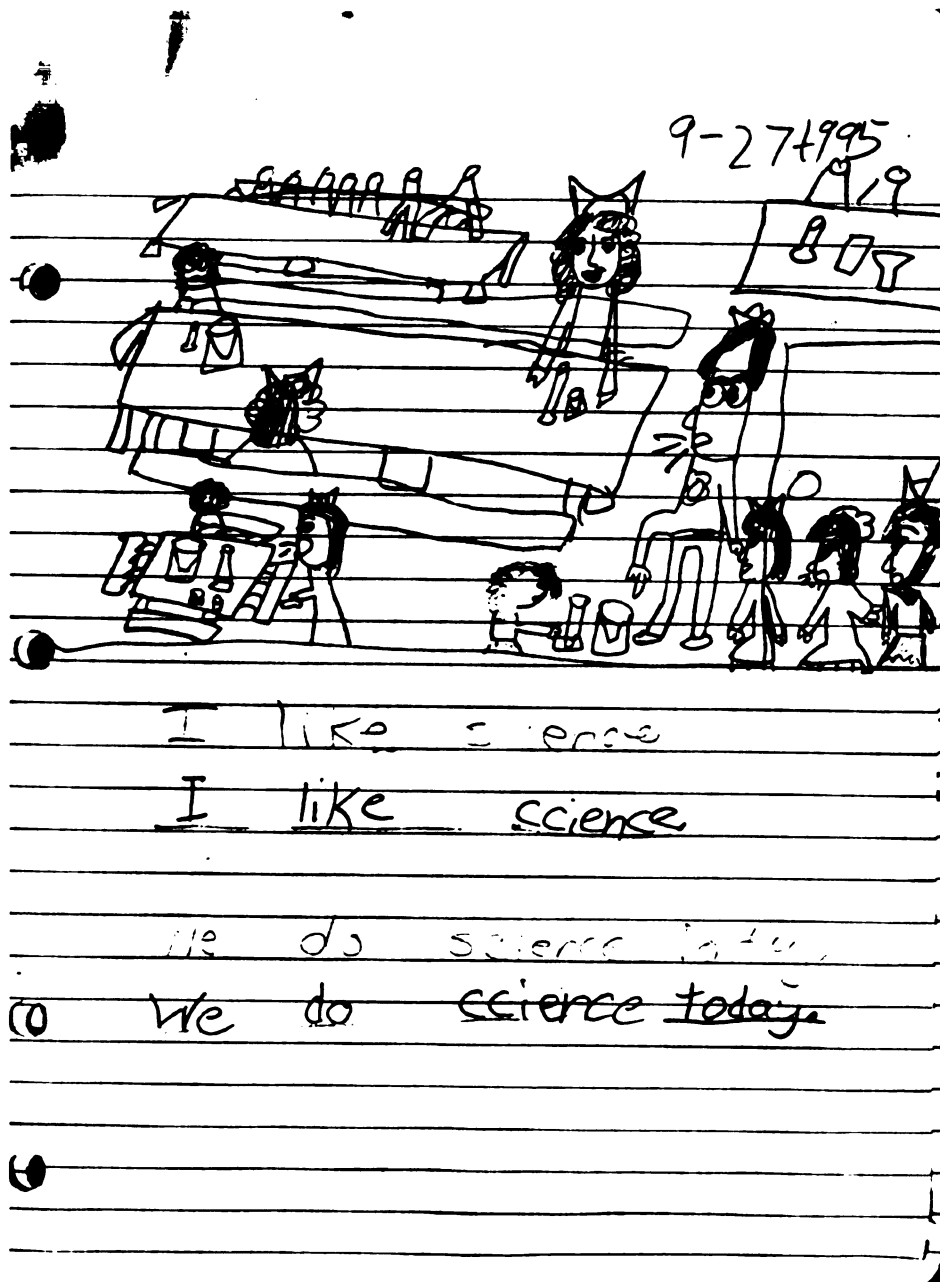


Figure 7.21 - Example of Integration of Knowledge, Language and Subjectivities Themes in Janine's Journal

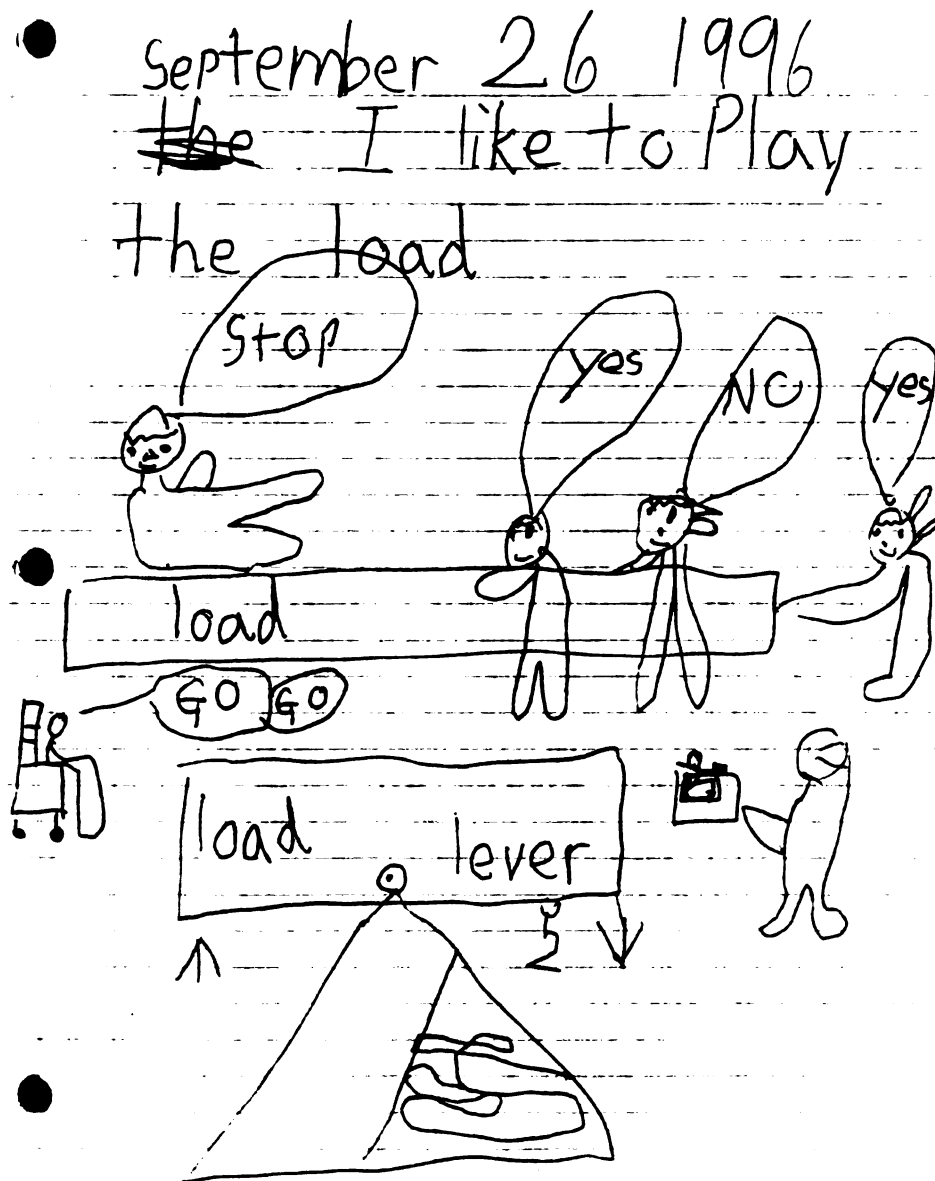


Figure 7.22 - Example of Integration of Knowledge, Language and Subjectivities Themes in Joey's Journal

• May 27, 1997
My story
About My
Boat
My boat was made
of the fet feather,
clay, and stiropnone.
• It could carry 3 ~~mr~~
marbles and 1 →

Figure 7.23a - Example of Integration of Knowledge, Language and Subjectivities Themes in Kamila's Journal

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~~sub~~ cup. This was
not my first boat
~~my first boat~~
~~my friend~~ about
my first boat I
was writting in
the story: My Boat
that boat sunk
becouse my freind
 pushed on

Figure 7.23b - Example of Integration of Knowledge, Language and Subjectivities Themes in Kamila's Journal

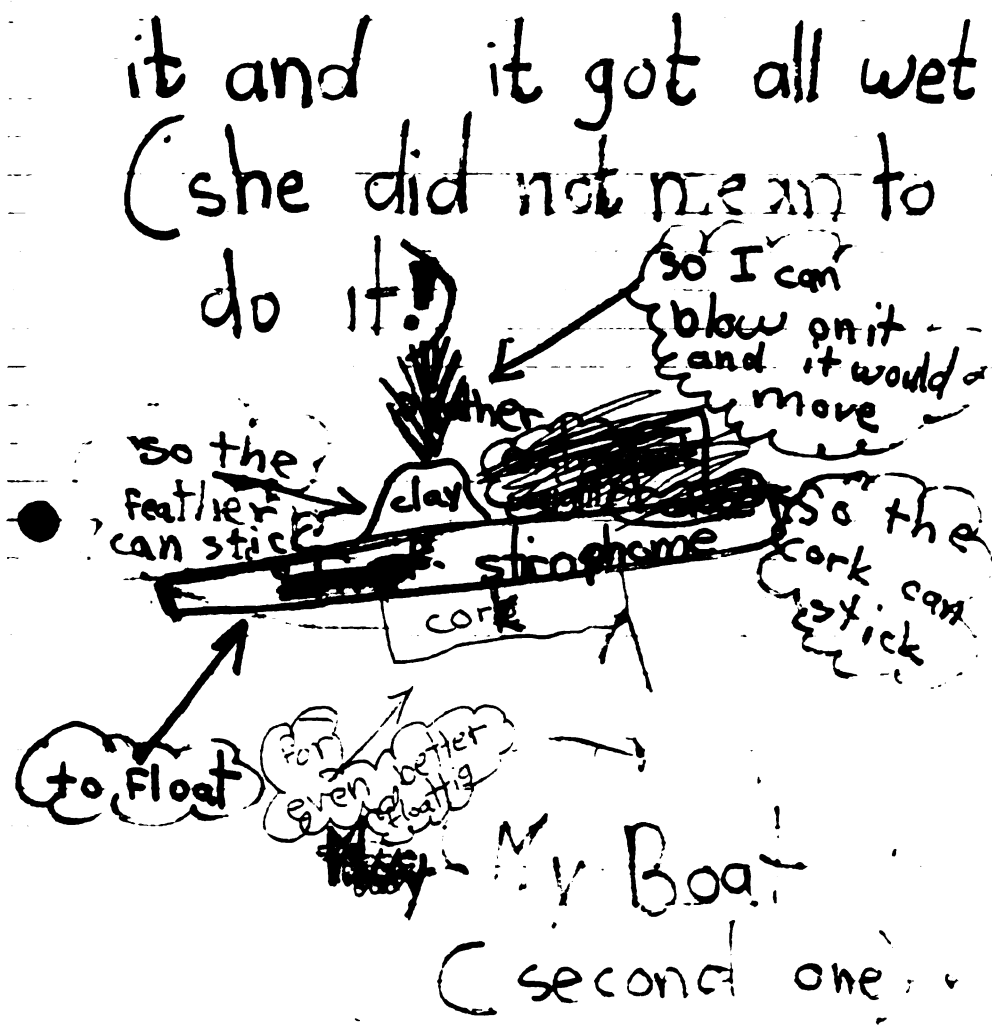


Figure 7.23c - Example of Integration of Knowledge, Language and Subjectivities Themes in Kamila's Journal

My Two Bats

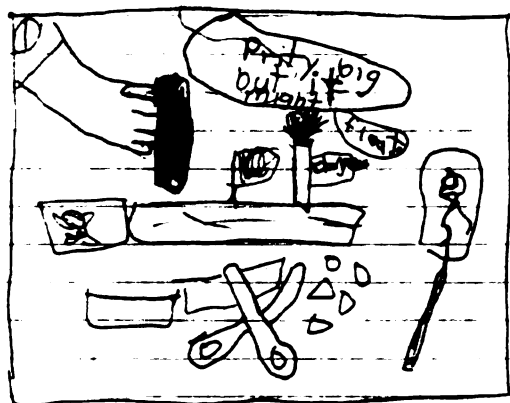


Figure 7.23d - Example of Integration of Knowledge, Language and Subjectivities Themes in Kamila's Journal

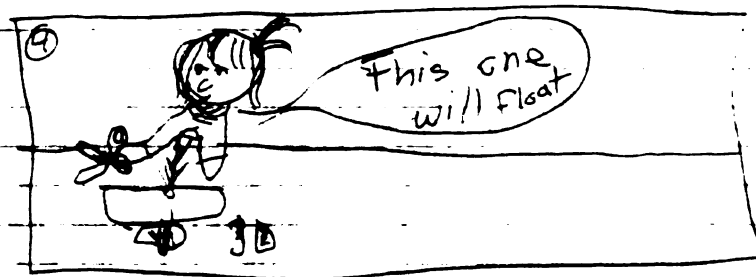


Figure 7.23e - Example of Integration of Knowledge, Language and Subjectivities Themes in Kamila's Journal

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Chapter 8

INTEGRATING KNOWLEDGE, LANGUAGE AND SUBJECTIVITIES IN A SCIENCE DISCOURSE COMMUNITY

Introduction

In this chapter I return to the questions I had in the beginning of this study. First, I revisit the question, “What was really going on?” To answer this question, I review the findings of discourse community norms, knowledge, language and subjectivities individually and discuss the interrelationships among them. Second, I consider if the apparent high levels of access and participation by students in science were really happening. This question is addressed by reexamining the discussion of findings across analyses using the recurring theme of expansions and constraints of classroom discourse. I then speculate on what implications these findings have for further research.

I follow this discussion with the query, “What specifically made these classrooms accessible and engaging places to learn science?” Two implications of this work describe some important characteristics of these classrooms regarding access, engagement and a broader vision of science. These characteristics may also provide effective models for use in other classrooms. As demonstrated here, knowledge, language and subjectivities should be central concepts in the practices of science classrooms and possibly extended to the science community. In establishing and integrating knowledge, language and subjectivities, the use of alternative and

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Finally, in answering how the teachers were able to encourage and facilitate such meaningful talk and thinking about science in young children, a third implication is asserted from this work. In order to provide a safe, comfortable and meaningful learning environment, student and teachers must jointly construct classroom discourse norms, talk and writing in specific ways.

While many educators have extensive conceptions of what knowledge and language (less of subjectivities) mean, their enactment in these elementary classrooms was both unique and enriching, providing a broader, more accessible vision of science. Overall, teachers, students and perhaps even scientists would benefit from broader visions of science which enrich science knowledge and practice and engage and value participants from many varied backgrounds.

Summary of Analysis Chapters

To address “what was really going on” in these classrooms, I begin with a summary of the four analyses in this study. The first analysis identified some of the norms and characteristics of the science discourse communities studied. Next, I focused on individually analyzing three key constructs in these science discourse communities. I considered knowledge construction and sources in circle conversations. I then looked at narrative and paradigmatic language features in the circle conversations. Finally, I identified the presence of subjectivities themes in students’ journal writing and drawing.

Norms and Characteristics of a Science Discourse Community

In the first analysis, some norms and other characteristics of the science discourse communities were made explicit by the entry of two new students, Uchenna

and Juwan, into the science classrooms. As the new students attempted to gain entry into the circle conversations, the entire communities underwent a *transformation of participation*. Initially, the new students acted in ways stereotypical of their genders but acted less so as they became part of the discourse communities. The new students also came to these classrooms with more authoritarian views of truth. Through the construction of the communities as student operated and the use of the discourse components, *agreeing* and *disagreeing*, other students had developed a location of authority within individuals. The new students required time and practice to adjust from traditional, external conceptions of authority to internal, individualistic understandings.

Particular norms helped to make the discourse community largely student operated. These norms included the present speaker having responsibility for selecting the next speaker, raising your hand when you wanted to speak, speaking only if you had been called on and listening and looking at the speaker. One structural norm of the conversations was that student contributions should be statements of agreement or disagreement with the statement being discussed or another student's response. Following stating agreement or disagreement, students could then add reasons for their opinions. Another norm regarding the content of statements was that contributions were given in the belief that they were relevant to the topic at hand. In addition, a general social norm was that students should speak and listen in respectful ways. Students took on primary responsibility for upholding these norms of participation with some assistance by the teachers for norms of topic relevance and respect.

Students also quickly internalized and maintained responsibility for most of the norms about authority within the individual. The principal norm was there was a

considerable amount of authority about “truth” located within the individual. Everyone also had a right to her or his own opinion and to change that opinion if desired. Reasons for the opinions of individuals were encouraged but not required.

A great deal of teacher support, however, was required in establishing and sustaining norms regarding equal access to the conversations. These norms included giving every student wishing to make a contribution an opportunity to participate, speakers allowing first turns for all interested contributors before granting second turns, and students taking responsibility for including all students in the discussion.

In order to create an equitable discourse community, the teachers employed specific strategies to help create a safe and comfortable conversation space and to facilitate student ownership. These strategies included commenting when a norm had been well adhered to or violated. To ensure maximal participation, teachers would instruct students to call on others who had not yet had a turn, point out particular students who had not been called on, or would step in to call on a student who had been ignored on several occasions. Teachers also explicitly established a rule that everyone who wished to speak should have a turn before other speakers had second turns. The discourse communities developed through an ever changing balance between lessening teacher support and gradually increasing student appropriation and responsibility for the conversations.

After establishing some of the working operations of the discourse community, I next explored the constructs of knowledge and language in the circle conversations and subjectivities in the students’ journals. These constructs were informative in further analyzing the rich interactions among students in their science activities.

Construction and Sources of Knowledge in Circle Conversations

In terms of knowledge, I analyzed convergence, divergence and gender influences on knowledge construction as well as students' sources of knowledge. I first determined that the circle conversations followed both convergent and divergent paths of knowledge construction. Convergent conversations were characterized by similar topic claims with divergent but complementary reasons creating a point of consensus around which students could explore and develop their reasoning. Convergent conversations often produced a sense of common understanding in the community. Complementary reasons in convergent conversations sometimes developed a depth of topic by progressing through increasingly complex concepts as students pushed simple ideas to deeper understandings. Both divergent claims and reasons characterized divergent conversations in which students broadened the breadth and complexity of the original topic. Divergent conversations often raised interesting, open-ended questions about a scientific topic. Sometimes, a number of related, complex issues were brought to bear upon the beginning topic. Occasionally, students pursued productive side trips by exploring issues of interest related to the topic claim.

Gendered construction of knowledge occurred in both convergent and divergent conversations. Gendered construction of knowledge was defined as same gender students elaborating the reasoning of previous same gender speakers. The progressive elaboration of reasoning by same gender speakers (gender clusters) resulted in a collaborative development of the floor.

Students used both formal and informal knowledge sources to substantiate their contributions to the science conversations. Students mostly drew on informal knowledge sources from themselves and others. The most predominant individual

sources were *personal experiences* and references to *other students*. Students also drew significantly on formal school-based knowledge, in particular *abstract logic* and sometimes *thought experiments*. Students rarely used *text and media* or gave *no knowledge* sources for their reasons. Often, interactions occurred between *self and others* and *school-based knowledge* demonstrating fruitful combinations of formal and informal knowledge. These combinations were often employed in convergent conversations. Students would use *personal experiences* and *abstract logic* together to exemplify general scientific principles with concrete instances. Many students followed this productive pattern as they reached consensus about a topic. A different feature characterized divergent conversations. References to *other students* were important as students mentioned specific previous students in keeping track and developing numerous lines of argument.

In terms of gender, both girls and boys equally referenced *personal experiences* as their primary knowledge sources. However, boys were also more likely to mention *other students* than girls. When referencing other students, both genders mainly agreed with same gender speakers. When disagreeing with other students, though, both genders were more likely to disagree with boys.

There was also a trend in knowledge sources according to topic but not over time. The major knowledge source in life science was *other students*, while the major knowledge source in physical science was *personal experiences*. Over time, there was a fairly consistent use of knowledge sources.

Narrative and Paradigmatic Language in Circle Conversations

I next focused on students' use of narrative and paradigmatic language features in the circle conversations according to time, topic and gender. All students used

narrative, paradigmatic and combinations of language forms at the beginning of the year. Students then moved towards more paradigmatic language features in their conversations as the year progressed. However, narrative reasons still often provided key, fruitful events in conversations where paradigmatic features were predominant.

Students used narrative to a slightly greater degree in life science topics and paradigmatic language more with physical science topics. Students may have felt closer to life science topics based on experiences with the world. The specific language features used by students when talking about life vs. physical science topics supported this interpretation. In life science conversations, students were more likely to reference a specific, concrete experience or example using the narrative features of *plot* elements, *subjectification*, *particularity* and *believability*. When a concept was more removed from their experience as in some physical science conversations, they tended to make contributions in a paradigmatic mode with *abstract*, *general*, *universal* and *logical* features.

I next subdivided the students' contributions by topic claim and reason, the structure established by the teachers for the conversations. Topic claims were primarily composed of paradigmatic features, particularly the *universal* feature. The narrative feature, *psychic reality of self* was also prevalent because of the teacher modeled format for topic claims, "I agree or disagree (*self* feature) with the statement (*universal* feature). Students mostly followed the teachers' format for expressing topic claims. However, life science topics contained somewhat more narrative features than physical science claims. For life science claims, students would sometimes specify a claim to a particular context, whereas physical science claims largely followed the teacher modeled format using the original *universal* topic statement.

Students' reasons had a greater diversity of features than topic claims. Reasons were less structured and largely determined by students with the only restrictions that they be relevant and nonfictional. As with topic claims, life science reasons had more narrative character, and physical science reasons had more paradigmatic character. Life science reasons included high use of *other*, *particular* and *comprehensible* narrative features. Physical science reasons included high use of *abstract*, *general*, *universal* and *logical* paradigmatic features.

There were no qualitative differences by gender in narrative or paradigmatic expression, but there were differences in number of turns and total number of narrative and paradigmatic features expressed. In Mrs. G's class, boys expressed more narrative and paradigmatic features per turn than did girls. In Mr. K's class, boys obtained more turns than girls over time.

Overall, students mostly spoke from the perspective of their own *selves* in topic claims but spoke from the perspective of an *other* in their reasons. Students may have been comfortable expressing a personal, subjective opinion about the topic claim presented to the whole class. Indeed, the structure for claims presented by the teachers was in reference to oneself, "I agree or disagree with the statement." Interestingly, students often then removed themselves and referenced an other, outside reason to support their claims.

These results may indicate a transitional stage as students move from narrative to paradigmatic modes in school science. This conversational model may also provide students with the freedom to use both narrative and paradigmatic modes as best suits the context in which they are speaking. These conversations show that narrative and

paradigmatic language can be used together in complementary, meaningful ways. The two modes need not be in opposition, and can, in fact, enhance each other.

Subjectivities in Journal Writing and Drawing

Finally, I analyzed students' science journals for the presence of subjectivities, personal and social observations and characteristics. These personal expressions were found in the majority of students' journal entries. I also found specific trends by gender, topic and time. Girls expressed subjectivities themes in their journals more often than boys. All students expressed subjectivities themes more often for life science topics than for physical science topics. These patterns may be due to typical socialization expectations that girls are more likely to express themselves personally than boys and that people feel more personally connected to life science than physical science. The differences were not extensive, however, as subjectivities themes were present in the majority of both boys' and physical science journal entries. The presence of subjectivities themes also increased over the school year possibly indicating the support of the classroom communities for this kind of writing and drawing or students' increased personal engagement with science in this context.

Specific subjectivities themes found in the student journals included *self and human elements, thinking, emotions, gender marking, culture, collaboration and interaction* and *flexible student and teacher roles*. By far, the most common theme was *self and human elements*. Secondly, students expressed the theme of *emotions* in their journals followed by *thinking, gender marking* and *collaboration and interaction* all to a similar degree. Only a small number of references were found for the *culture* and *flexible student and teacher roles* themes. Few differences were found in the frequency of specific subjectivities themes by gender, topic or time.

The journal writing and drawing provided a complementary form of discourse to the circle conversations previously analyzed. The subjective, *collaboration and interaction* theme and the language theme of *conversation* were present in both oral and written discourse demonstrating the overlap of features and continuity between these discourse forms in the classrooms. Different students used conversation and writing to varying degrees suggesting the access value of allowing multiple forms of expression for students. The wide range of freedom in both discourse forms allowed students to fully represent and communicate their science experiences.

Summaries of Trends across Analyses

In each of the knowledge, language and subjectivities analyses, I identified trends for each construct according to the categories of gender, topic and time. Gender was also an important focus in the case studies of the new students. Here I summarize the trends by gender, topic and time across the analyses and consider the integration of knowledge, language and subjectivities in student talk and writing.

Trends by Gender

Gender was an important subjective influence on students' science interactions in these classrooms. In first examining the new students entry into the classroom, stereotypical gender patterns were seen in the new students' behaviors. Uchenna's shy behavior made her unnoticed by her peers. Juwan's very vocal behavior demanded that he be noticed and included in the science conversations from the very beginning of his entry. As the new students became familiar with the other students and moved to full participation in the discourse communities, they moved away from behaviors stereotypical of their genders.

Gender was also an important factor in the knowledge and language constructs of the circle conversations. Knowledge in the conversations was often constructed according to gender as students collaboratively developed reasoning for a topic claim in a series of same gender turns. There were similarities and differences by gender in students' use of knowledge sources. Both girls and boys referenced *personal experiences* as their primary knowledge source, but boys were more likely to reference *other students* than girls. In referencing other students, there were also clear gender patterns. Both genders were more likely to agree with the same gender. However, they were also both more likely to disagree with boys rather than girls.

For narrative and paradigmatic language expression in the circle conversations, both girls and boys used the same variety of features. However, in Mrs. G's class, boys expressed more narrative and paradigmatic features per turn than did girls. In Mr. K's class, boys obtained more turns than girls over time.

In journal writing and drawing, girls expressed subjectivities themes more often than boys. Both genders, however, expressed the particular subjectivities theme, *gender marking*, to a similar degree. *Gender marking* was defined as an explicit reference to someone by gender in students' writing or drawing.

In the circle conversations, there was clearly alignment by gender in the knowledge construction and references to other students as knowledge sources. In addition, the language analysis demonstrated differential access to the conversations. Boys had greater access than girls either by taking longer turns in which they expressed more language features or by obtaining more turns over time. Girls, however, seemed more comfortable expressing their subjectivities in their journals. Girls appeared to have

more access to the individual private discourse form of writing than they did to the whole class, public conversations.

Trends by Topic

Trends according to life and physical science topics were found both in students' circle conversations and writing. Students mostly drew on informal knowledge sources for both life and physical science topics. However, the primary specific knowledge source in life science was *other students*, while the primary knowledge source in physical science was *personal experiences*.

In terms of language, students used narrative features to a slightly greater degree in life science topics and paradigmatic language more often with physical science topics. Both topic claims and reasons had more narrative character in life science, and both had more paradigmatic character in physical science. Life science reasons mainly included *other*, *particular* and *comprehensible* narrative features. Physical science reasons predominantly included *abstract*, *general*, *universal* and *logical* paradigmatic features.

In journal writing students expressed more subjectivities themes in life science as compared to physical science, but the differences were not great.

Overall, students used more nontraditional forms of expression in life science (informal knowledge sources, narrative language and subjectivities themes) than in physical science. These findings fit with the conception that life science topics are more closely tied to people's personal experiences and so would lend themselves to more personal, nontraditional forms of expression.

Trends over Time

There were no discernable knowledge patterns over time. In the language analysis, however, students moved over time towards using more paradigmatic features

than narrative features in the circle conversations. The presence of subjectivities themes also increased in science journal writing over time.

These two patterns at first appear to be in opposition. Over time, there was more traditional language expression in conversations but also an increase in subjectivities expression in writing. As with the gender findings, however, students may have felt more freedom of expression in private, individual writing as compared to a public, whole class forum.

Integration of Knowledge, Language and Subjectivities in Student Talk and Writing

Knowledge and language were subjects of analysis for students' talk in the circle conversations. Convergent and divergent construction of knowledge as well as use of formal and informal knowledge sources were established in students' science talk. Use of both narrative and paradigmatic language features was also identified in the circle conversations. In addition, one subjective feature gender was recognized in both the knowledge and language analyses. Gendered construction of knowledge was established in the circle conversations as well as differential use of the specific informal knowledge source, *other students*. Boys used this knowledge source more often than girls.

While gender was a highly visible subjectivities factor, other subjectivities features can be readily seen in the circle conversations. Students principally referenced themselves through the use of *personal experience* knowledge sources and narrative *psychic reality of self* features. Another subjective feature, *other people*, was also referenced in students' informal knowledge sources and narrative language features. While culture, an important subjectivities feature, was not often explicitly referenced,

it played a key role in some conversations with specific cultural knowledge sources noted.

The knowledge, language and subjectivities features interacted in complicated ways to produce the rich and meaningful science conversations accessible to many students in these classrooms. A simple example is *subjective* expression in the conversations through the gendered construction of knowledge. These complex conversations also followed convergent and divergent *knowledge* paths and contained both narrative and paradigmatic *language* features.

In journal writing and drawing, students also expressed many language and knowledge themes in addition to subjectivities. A predominant language theme was *conversation* as students sometimes drew themselves talking with other students through the use of dialogue balloons. A key knowledge theme was *active forms of knowledge*. Students often portrayed themselves and others actively involved in science experiments. Overall, students presented rich, detailed portraits of their science experiences both expressing and integrating subjectivities, language and knowledge themes. Generally, students made drawings of themselves and other students (*subjectivities* theme) talking together (*language* theme) as they actively worked (*knowledge* theme) on a scientific investigation.

Expansions and Constraints to the Discourse

In reflecting on the analyses, I next evaluate whether the apparent high levels of access and participation by students in science were really happening. I observed and documented extensive access and engagement by the students in these classrooms in the circle conversations, journals or both. However, there were also some ways that access to science participation was limited. I examine both the opportunities and

limitations of access and engagement using the theme of expansions and constraints to the discourse.

In looking across the conversations and journals, these innovative interactions included both expansions and constraints to the discourse. Ways in which the discourse was expanded and constrained within the knowledge, language and subjectivities constructs are summarized below.

Conversations were *expanded* by convergent paths of knowledge construction and gender clusters which provided a core of common knowledge around which students could explore and develop divergent reasons in a safe context. Divergent conversations also expanded the discourse by allowing an open forum in which students could pursue an array of related, key issues relevant to the topic under question. Gender clustering within the divergent conversations may have permitted more students to feel comfortable and included in the conversations and may have furthered the conversations by allowing students to more freely develop ideas cohesively and collaboratively. Conversations were also expanded by both formal and informal knowledge sources and the intersection of these two allowing exploration of concrete instances (personal experiences) and abstract concepts (school-based knowledge). Formal and informal sources helped students to see science as part of their lives both in and out of school. These broad knowledge bases gave access to science conversations for most of the students.

Conversations were also *expanded* by the use of both narrative and paradigmatic features. The conversations had great variety in language forms with narrative features sometimes emphasized, paradigmatic features sometimes emphasized, and interesting combinations of both language forms occurring. In

addition, the lack of qualitative differences in types of features used by each gender indicated that both genders were comfortable and competent with both narrative and paradigmatic language forms.

The rich, holistic student journal writing and drawing in many ways *expanded* the discourse through students' essential personal expressions and integration of these subjectivities with knowledge and language. The teachers, Mrs. G and Mr. K, encouraged students to fully express themselves in their science writing and drawing. In so doing, students used a variety of nontraditional and traditional forms to represent and communicate their science experiences integrating subjectivities, language and knowledge. The students' subjective expressions represent a more personal, connected way of interacting with science.

On the other hand, there were also some constraints in these innovative discourse communities. Conversations were sometimes *constrained* by convergent paths of knowledge construction which were at risk of being short and superficial. At times, divergent conversations ran the risk of becoming a loose, disconnected set of isolated ideas. There was also the chance of students becoming sidetracked to the point of evading the original topic all together. Gender clusters may have constrained conversations if students saw their own gender only as potential speakers. Limiting or favoring one or a few knowledge sources contributed to constraining the discourse on occasion.

Conversations were also *constrained* by the use of more paradigmatic features over time. Students may have learned in other contexts that paradigmatic language is the traditional language used in formal science, and they may have attempted to adopt this as their primary language form in their school talk. Students may also have been

constrained by preferentially using one language form according to the conversation topic. Students used narrative language in life science topics more than in physical science topics. Moreover, the conversations were limited by gender. Mrs. G's boy students obtained longer turns in which they expressed more language features, while Mr. K's boy students received more turns than did girls over time. Each gender trend shows that boys had more opportunities to practice the discourse, both narrative and paradigmatic forms, than did girls.

In a few ways, the discourse may have been *constrained* in the students' science journal writing and drawing. There was a somewhat greater presence of subjectivities themes in girls' journals and in life science topics. Girls are often considered to be more personally expressive than boys. While the difference between the girls' and boys' expressions of subjectivities is not large in this analysis, it may signify the beginning of a trend that could become more pronounced over time. Similarly, life science topics are considered to be more open to personal expression than physical science topics. Fortunately, the small differences at this grade level could be overcome with more encouragement of personal expression in science for all topics by both girls and boys.

Implications for Research

Many research studies have looked separately at various aspects of knowledge (e.g., Bishop & Anderson, 1990; Edwards & Mercer, 1987; Posner, Strike, Hewson & Gertzog, 1982), language (e.g., Driver, Newton & Osborne, 2000; Louden, 1998; Lyle, 2000; Snow & Kurland, 1996) and subjectivities (e.g., Davis, 1989; Hazelwood, 1996; Weiler, 1998) in classrooms. Obviously, it is easiest to focus on one factor at a time as classrooms are complex, dynamic environments. In narrowing in on one factor, we can gain great insights into its role in the classroom. However, in focusing, we sometimes do

not take into consideration the larger context and interplay of multiple factors that make up the classroom as a whole. Both types of work, focused and holistic, are necessary and complementary in helping us to better understand the complicated workings of classrooms.

This study is located somewhere between focused and holistic research. The multiple foci of discourse norms, knowledge, language and subjectivities provided a richness to the description of the classrooms that would not have been possible with a single focus of study. The multiple foci also permitted some synthesis in understanding the complexity of the students' interactions with science. However, a complete understanding of students' science experiences was not possible with this work and requires further research using an integrated approach.

In this study I first attempted to gain a broad understanding of the classroom by identifying some of the key characteristics of science conversations. This analysis contributes to the research literature by identifying specific norms which led to the creation of student owned discourse communities. However, further work would greatly contribute to this analysis. While the entry of the new students, Uchenna and Juwan, provided an opportunity for me to more clearly see the norms operating within these unique discourse communities, I have further questions worth pursuing. What does it mean to establish the norms? What actions do the students take, and what actions do the teachers take? How are new norms introduced and taken up by the communities?

Following my analysis of the discourse communities, I then attempted to gain a deeper sense of the students' talk and writing by studying three key constructs, knowledge, language and subjectivities. These constructs served as useful tools to gain

some understanding of student access and engagement. These analyses were necessary first steps yielding informative insights and methodological tools that may be used in future research. However, this study would clearly benefit from further understanding how the constructs of knowledge, language and subjectivities are integrated in the classroom setting and how that integration can support equitable access and rich, meaningful learning by all students in a safe and comfortable environment. In addition to further work from the perspective of the whole classroom, in-depth case studies elucidating individual students' multiple interactions with knowledge, language and subjectivities would benefit the research and teaching communities.

This study allowed me to gain a beginning understanding of the complex and exciting interactions in these science classrooms. The individual analyses provided me with some sense of what was going on, but they were still mere glimpses of the complete array of the students' and teachers' science experiences. Further, in-depth examination of the question, "What is going on here?" is worth pursuing in other contexts in these and other classrooms so as to develop a fuller understanding of students' and teachers' interactions with science. In addition, I return to another beginning question. Were the apparent access and participation by students in science really happening? The analyses documented high levels of access and participation in science through the use of alternative and traditional forms of expression in classroom practices. However, each analysis also revealed particular constraints in the discourse. In future research, I would like to better understand these constraints and work towards eliminating or, at least, minimizing them.

While this study provided some specific ways to increase access for students through a broader vision of science, the link between access and learning remains

elusive. Certainly, access is a necessary starting point that must be successfully navigated in order for meaningful learning to have the opportunity to occur. However, explicit ties between access and learning were not sufficiently examined in this study. The detailed case studies of individual students suggested earlier may also provide specific evidence establishing the necessary connections between access and learning. Case studies would also give a personal, individual perspective that would complement the largely whole class views presented in this study.

Finally, the research presented here was conducted in elementary science classrooms, yet was informed by feminist critiques of the discipline of science. Even though some of the findings from this study seem to naturally extend to professional science communities, further documentation of similar and different practices among scientists that expand or constrain access to science are worth investigating.

Implications for More Accessible, Inclusive and Meaningful Science Experiences

Two implications of this work address my beginning research question, “What specifically made these classrooms accessible and engaging places to learn science?” First, knowledge, language and subjectivities should be central concepts in the practices of science classrooms. Second, in establishing and integrating knowledge, language and subjectivities in the science classroom, alternative and traditional modes of expression should be supported as both necessary and complementary.

A third implication responds to the research question, “How were the teachers able to encourage and facilitate such meaningful talk and thinking about science in young children?” A safe, comfortable and meaningful learning environment requires joint student and teacher construction of discourse norms, talk and writing in specific ways.

These implications may serve as models for other classrooms and possibly the discipline of science itself. Further explanation of each of these implications follows below.

Knowledge, Language and Subjectivities as Central Constructs

Knowledge, language and subjectivities are constructs that have been studied extensively in education. However, few studies (e.g., Weiler, 1999) consider the centrality of all three constructs in effective classroom practices and in the discipline of science itself. These constructs capture to some degree the variety and expanse of classroom practices used by the students and teachers in this study to ensure equitable access to and meaningful engagement in a broad vision of science.

Figure 8.1 depicts a model of knowledge, language and subjectivities in classroom discourse. The right side of the diagram illustrates the presence and integration of all three constructs. In this case, classroom discourse is expanded as demonstrated by the practices of rich student conversations, writing and drawing seen in this study. The left side of the diagram represents the limited presence of one construct. This leads to constraints in classroom discourse as illustrated by traditional classroom practices such as teacher lecturing in which the sole focus is science knowledge. The next section further discusses the variety of alternative and traditional modes of expression used by the students within each construct.

Employment of Alternative and Traditional Modes of Expression as Necessary and Complementary

In establishing and integrating knowledge, language and subjectivities, science learning may benefit from the use of both alternative and traditional modes of expression as both necessary and complementary. Traditionally, students were limited to a few

modes of expression in science. It is now well established that students benefit from multiple forms in which to express themselves. Yet, students vary in their degree of experience and comfort with different classroom formats. Some educators have created a dichotomy of forms favoring either traditional (didactic) or alternative (inquiry) forms of expression in science classrooms. However, the students and teachers in this study showed how traditional and alternative forms of expression could be used together in rich and complementary ways. Figure 8.2 illustrates the specific alternative and traditional modes of expression used by students in this study which may also serve as a model for other classrooms.

For knowledge, traditional forms included convergent knowledge construction and formal knowledge sources. These forms might be enacted in traditional classrooms where students are expected to understand a single or narrow set of science ideas originating from a formal, authoritative source such as the teacher or a science text. Alternative knowledge forms included divergent and gendered knowledge construction and informal knowledge sources. Classrooms using alternative knowledge forms would support multiple paths of knowledge construction sometimes aligned by gender and using a variety of informal knowledge sources such as personal experiences or other students. In the classrooms in this study, all of the above alternative and traditional knowledge forms were necessarily used together to ensure rich, meaningful understandings by students. The alternative and traditional modes of expression acted in complementary and connected ways leading to fuller development of knowledge.

For language, traditional forms included written and paradigmatic expression. In traditional classrooms students are expected to use a paradigmatic mode to express their science understandings, and these understandings are usually communicated in writing

through worksheets, lab reports and tests. Alternative forms of language, however, include narrative and oral expression. In an alternative classroom, students might be encouraged to use story to communicate their understandings of science, and this communication might occur through conversation. Again, the classrooms in this study valued and used all of the above alternative and traditional forms of language expression in complementary ways to communicate full, deep understandings of science.

Subjectivities are not an explicit feature of traditional science instruction. Personal and social observations and characteristics are not considered part of traditional, objective science facts. However, subjectivities are valued in an alternative classroom which sees science as a human construction in which the products of science are integrally tied to their human producers. The teachers in this study welcomed and encouraged students' subjective expressions in science. The students themselves saw the subjective elements as necessary to their complete expression of their science experiences.

This study shows some specific alternative and traditional forms of expression that may be employed by teachers and students to create more inclusive classrooms that provide meaningful science experiences accessible to many students. These forms of expression could also be extended to the practice of science to make it more accessible and inclusive as called for by feminist philosophers of science (Haraway, 1996; Harding, 1991; Hubbard, 1989; Keller, 1985).

Joint Student and Teacher Construction of Discourse Norms, Talk and Writing

In educational settings we see great variety in the responsibilities of students and teachers for classroom practices. Traditionally, teachers were considered to have sole

responsibility for setting up and monitoring classroom practices usually taking the primary role of lecturing to students. More recently with the increasing popularity of social constructivism (e.g., e.g., Cobern, 1998; Peasley, 1996; Shymansky & Kyle, 1992; Staver, 1998), we have seen movements towards students taking on more responsibility for the practices in their classrooms. While most social constructivist educators advocate a joint construction by students and teachers of classroom practices, it is not always clear what responsibilities each should take. In this study specific student and teacher duties were identified for discourse norms, talk and writing. The set of shared student and teacher responsibilities in these classrooms led to a comfortable relationship between the students and teachers. Teachers focused on student learning of important science ideas in a safe, equitable environment. Students took major responsibility for their own learning using a full range of expression forms to more fully and meaningfully develop their understandings of science. Students and teachers each had specific responsibilities for classroom practices with some overlap of duties. Their practices may serve as a model for other classrooms. Figure 8.3 illustrates the joint construction of student and teacher responsibilities for discourse community norms, conversations and journals. Each practice is represented by a set of concentric circles with the inner circle representing the principal construction of the teacher and the outer circle representing the principal construction of the students. Blurring between concentric circles represents areas of overlap between student and teacher responsibility.

For the practice of discourse community norms, students largely took on the responsibility for norms regarding how to participate in conversations and locating authority within individuals. Teachers, on the other hand, took primary responsibility for norms regarding access to the conversations. There is a large amount of blurring between

the areas of student and teacher responsibility as students and teachers moved easily between them.

Conversations and journals had more clearly delineated roles for students and teachers with less overlap of responsibilities. For science conversations teachers were responsible for constructing a topic claim, a key science statement or question that would be the focus of the conversation. The form of this claim was highly structured as a universal statement or question. Students had full responsibility for developing and sharing reasons to support or negate the topic claim. Students also had a great range of freedom in how they expressed their reasons. Different forms of expression identified in this study included convergent, divergent and gendered paths of knowledge construction, formal and informal knowledge sources and paradigmatic and narrative language. There was much less movement between students and teachers in the conversation structure than in the discourse community norms. Students sometimes attempted to alter the content of the topic claims, but the teachers would then ask them to explain how their contribution was relevant to the original topic claim. While students usually followed the structure of the topic claim given by the teachers, they sometimes made structural changes permitted by teachers. For example, a student might change the topic claim from a universal statement to specifying a particular context. Teachers, on the other hand, almost never provided reasons for a topic claim and would only question a student's reason if it were fiction or seemingly irrelevant to the topic at hand.

Similar separation of responsibilities occurred in journal writing. Teachers were again responsible for choosing the science topic to be studied. Usually, the teachers designed a hands-on activity for students to explore the specified science topic. Students then had full responsibility to draw and write about their science experience in their

journals. While students always included the specific science topic in their journal entries, they expanded beyond the topic to present the science knowledge in an active form representative of their hands-on activity. They also conveyed a full range of expressions integrally linked to the science knowledge. These principally included their personal observations and characteristics (subjectivities) and conversation.

This example of joint student and teacher construction of classroom practices represents a concrete model that finds an effective middle ground between all student or all teacher responsibility. In this model students and teachers work together equally sharing responsibility for the enforcement of discourse norms ensuring an equitable classroom community in which all students have the opportunity to participate. While teachers determined the core science knowledge to be studied, students had the freedom to elaborate and extend that knowledge in a variety of forms ensuring rich, meaningful development of their science understandings. These students and teachers found a balance between structure and freedom which allowed students to comfortably participate in a discourse community and fully express their ideas about science.

Summary

In this chapter I revisited the big questions that framed this study. To determine what was really going on in these classrooms, I summarized the findings of each analysis in this study and examined trends across analyses. Norms of the discourse community were identified regarding how to participate, location of authority within individuals and access to science conversations. Convergent, divergent and gendered paths of knowledge construction along with informal and formal knowledge sources were ascertained in the circle conversations. Use of narrative and paradigmatic language features was also

determined in the students' conversations. Finally, the presence of subjectivities themes was identified in student journal writing and drawing.

Across analyses, trends were determined by gender, topic and time. Gender was an important factor influencing the new students' entry into the classrooms, knowledge construction and sources and access to narrative and paradigmatic language expression in circle conversations. In journal writing and drawing, students also differentially expressed subjectivities according to gender.

For life and physical science topics, students primarily drew on different knowledge sources and used different frequencies of narrative and paradigmatic language features in the circle conversations. Students also expressed subjectivities themes in their journals to a slightly greater degree in life science topics.

There were no knowledge patterns over time, but students' use of paradigmatic language features increased over time in the circle conversations as did their expression of subjectivities themes in their journals.

While each analysis focused on a single construct, the presence and integration of knowledge, language and subjectivities was observed in the students' conversations and journals. The integration of these constructs provided full, rich and meaningful expression of students' science experiences.

In reflecting on the findings, I examined the extent to which the apparent high levels of access and participation by students in science were really happening in these classrooms. I found the theme of expansions and constraints of classroom discourse useful in assessing the levels of student access and engagement. These innovative discourse communities provided multiple, varied opportunities for students to express themselves in science, and most children took advantage of at least some of these

opportunities. However, there were also some features which constrained the discourse. This research would benefit from further study of the integration of knowledge, language and subjectivities in whole class settings and in individual students.

Three broad understandings arise from this work which may be useful to other educators. The first two implications address my beginning research question, “What specifically made these classrooms accessible and engaging places to learn science?” First, knowledge, language and subjectivities should be central concepts in the practices of science classrooms and the discipline of science. Second, alternative and traditional modes of expression should be supported in both science classrooms and the discipline of science as necessary and complementary. A third implication responds to how the teachers were able to encourage and facilitate such meaningful talk and thinking about science in young children. Science learning can benefit from joint student and teacher construction of discourse norms, talk and writing in specific ways. Employment of these understandings can lead to more accessible, inclusive and meaningful science experiences.

Possibilities of Classroom Science Discourse

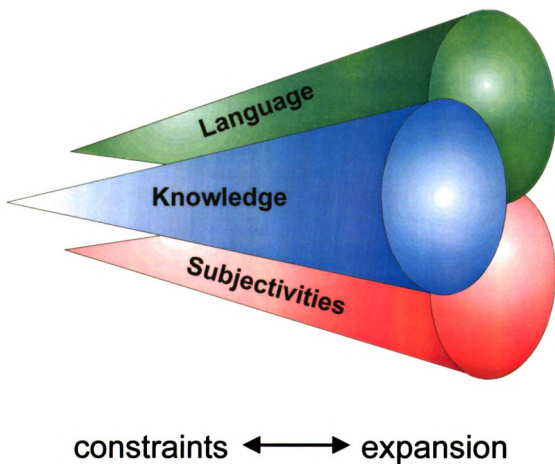


Figure 8.1 - Integration of Knowledge, Language and Subjectivities in Classroom Discourse

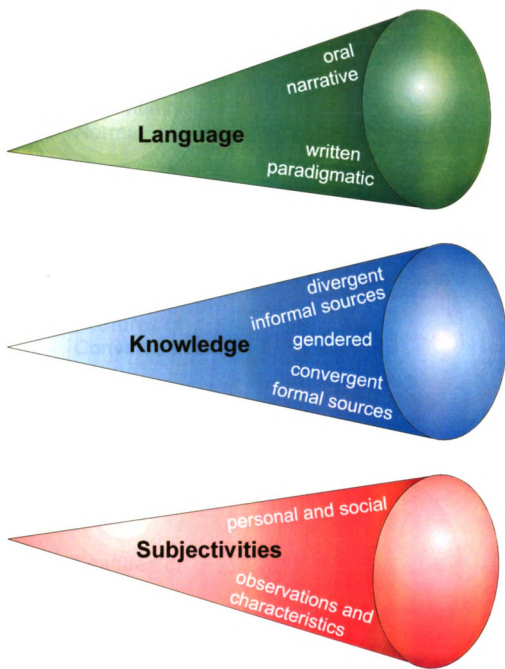


Figure 8.2 - Alternative and Traditional Forms of Expression in Knowledge, Language and Subjectivities Constructs

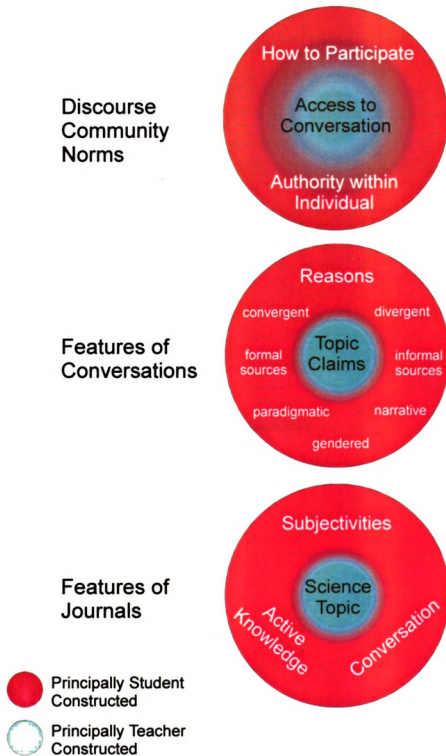


Figure 8.3 - Joint Student and Teacher Construction of Discourse Norms, Talk and Writing

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APPENDICES

APPENDIX A

Videotape Log of Mrs. G's and Mr. K's Science Classes and Interviews

Year 1 (1995-96)

Date	Class-room	Type of Interaction	Brief Description
9-6-95	Mrs. G	Whole class discussion Individual journal work	What are the parts of an eggbeater?
9-6-95	Mr. K	Whole class discussion Individual journal work	What are the parts of an eggbeater?
9-8-95	Mr. K	Whole class discussion	How many parts are in a pair of scissors?
9-8-95	Mrs. G	Whole class discussion	How many parts are in a pair of scissors?
9-11-95	Mrs. G	Whole class discussion	What do students know, want to know and how can they learn (KWL) about the land?
9-13-95	Mrs. G	Teacher modeling Small group work Individual journal work	Four different kinds of soil
9-20-95	Mrs. G	Whole class discussion Pair work	How is soil made?
9-22-95	Mr. K	Whole class discussion	Good soil is made of two materials.
9-22-95	Mrs. G	Whole class discussion	Good soil is made of two materials.
9-27-95	Mrs. G	Whole class discussion Small group work	Do all soils absorb the same?
9-27-95	Mr. K	Whole class discussion Small group work	Do all soils absorb the same?
9-29-95	Mr. K	Whole class discussion Individual investigation Circle conversation	Particle size investigation All soil is the same.
10-6-95	Mrs. G	Interview with Mrs. G (beginning of year 1)	Use of oral discourse components Student participation Dissonance between student and scientific ideas Teacher collaboration
10-6-95	Mr. K	Interview with Mr. K (beginning of year 1)	Use of oral discourse components Student participation Dissonance between student and scientific ideas Teacher collaboration
10-13-95	Mrs. G	Circle conversation	Plants can grow without soil.

Date	Class-room	Type of Interaction	Brief Description
10-13-95	Mr. K	Circle conversation	Plants can grow without soil.
10-20-95	Mrs. G	Circle conversation	All plants die in the winter.
10-20-95	Mr. K	Circle conversation	All plants die in the winter.
10-27-95	Mrs. G	Circle conversation	What happens to Michigan plants in the winter?
10-27-95	Mr. K	Circle conversation	What happens to Michigan plants in the winter?
11-3-95	Mrs. G	Circle conversation	Do all plants have stems?
11-3-95	Mr. K	Circle conversation	Can anyone plant wild plants?
11-10-95	Mrs. G	Circle conversation	Why didn't the small part of the earring get attracted to the magnet?
11-10-95	Mr. K	Circle conversation	Why didn't the small part of the earring get attracted to the magnet?
11-17-95	Mr. K	Teacher instruction Circle conversation	Magnets have more than three uses.
12-1-95	Mr. K	Whole class discussion	What do students know, want to know and how can they learn (KWL) about when dinosaurs lived?
12-8-95	Mrs. G	Circle conversation Teacher explanation	All dinosaurs are reptiles. Mr. K explains circle conversations to teacher interns.
12-8-95	Mr. K	Circle conversation	All dinosaurs are reptiles.
12-11-95	Mrs. G	Whole class discussion Small group work	Ancient and modern animal classification
12-11-95	Mr. K	Whole class discussion	Ancient and modern animal classification
12-15-95	Mrs. G	Circle conversation	Could meat eaters live if there were no plants on earth?
12-15-95	Mr. K	Circle conversation	Could meat eaters live if there were no plants on earth?
12-18-95	Mrs. G	Whole class discussion Pair work Pairs share with class.	Food chains
12-19-95	Mrs. G	Whole class discussion Small group work	Dinosaur footprints
12-20-95	Mr. K	Whole class discussion Small group work	Dinosaur models
12-20-95	Mrs. G	Small group and individual work	Dinosaur models
1-8-96	Mrs. G	Whole class discussion Individual journal work	Naming dinosaurs

Date	Class-room	Type of Interaction	Brief Description
1-8-96	Mr. K	Whole class discussion Individual journal work	Naming dinosaurs
1-9-96	Mrs. G	Individual sharing of stories with class Whole class discussion Individual work	Dinosaur footprint stories Drawing dinosaurs from fossils
1-11-96	Mr. K	Whole class discussion Individual work	Drawing dinosaurs
1-12-96	Mrs. G	Circle conversation	When did dinosaurs live? Did they live on earth at the same time?
1-12-96	Mr. K	Circle conversation	When did dinosaurs live? Did they live on earth at the same time?
1-19-96	Mrs. G	Whole class discussion	Planets, stars, sun, moon and space (KWL)
1-19-96	Mr. K	Whole class discussion	Planets, stars, sun, moon and space (KWL)
1-26-96	Mr. K	Circle conversation	The moon gives off its own light.
2-9-96	Mr. K	Circle conversation	The sun is always shining. The stars are always shining.
2-9-96	Mrs. G	Circle conversation	The sun is always shining. The stars are always shining.
2-15-96	Mr. K	Interview with Mr. K (middle of year 1)	Progression of oral discourse components Progression of student participation
2-15-96	Mrs. G	Interview with Mrs. G (middle of year 1)	Progression of oral discourse components Progression of student participation
2-23-96	Mrs. G	Circle conversation	Heavy objects sink in water.
2-23-96	Mr. K	Circle conversation	Heavy objects sink in water.
3-8-96	Mrs. G	Circle conversation	Water can change shape.
3-8-96	Mr. K	Circle conversation	Water can change shape.
3-15-96	Mrs. G	Circle conversation	People need water to live.
3-15-96	Mr. K	Circle conversation	People need water to live.
3-22-96	Mrs. G	Circle conversation	There is water in air.
3-22-96	Mr. K	Circle conversation	There is water in air.

Date	Class-room	Type of Interaction	Brief Description
3-22-96	Mrs. G	Interview with Darweshi (African boy; high level of oral discourse; moderate written discourse; high English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
3-22-96	Mr. K	Interview with Preston (Asian boy; high level of oral discourse; high written discourse; high English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
4-19-96	Mrs. G	Circle conversation	Is air real?
4-19-96	Mr. K	Whole class discussion	What do you know about air (KWL)?
4-19-96	Mrs. G	Interview with Janine (Asian girl; low level of oral discourse; moderate level of written discourse; intermediate English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
4-19-96	Mr. K	Interview with Rati (Asian girl; low level of oral discourse; moderate written discourse; intermediate English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
4-26-96	Mrs. G	Circle conversation	Does it matter what shape a boat has to float or carry a load in water?
4-26-96	Mr. K	Circle conversation	Does it matter what shape a boat has to float or carry a load in water?
4-26-96	Mrs. G	Interview with Justin (African boy; moderate level of oral discourse; moderate written discourse; intermediate English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
4-26-96	Mr. K	Interview with Gary (African American boy; high level of oral discourse; low written discourse; native English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal

Date	Class-room	Type of Interaction	Brief Description
4-30-96	Mrs. G	Whole class discussion Individual journal work Small group demonstrations	Shape, size and sides of boats
5-1-96	Mrs. G	Whole class discussion Individual work	Revising toy boats
5-2-96	Mr. K	Individual work Whole class discussion	Revising toy boats
5-3-96	Mrs. G	Circle conversation	The shape of the boat is really important.
5-3-96	Mrs. G	Interview with Sujata (Asian girl, low level of oral discourse; moderate written discourse; intermediate English language use) and Niranjana (Asian girl, low level of oral discourse; low written discourse; intermediate English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
5-6-96	Mrs. G	Mr. K reads story. Individual work Individual journal work	Revising, reading and writing about boats
5-6-96	Mr. K	Mr. K reads story. Individual work Individual journal work	Revising, reading and writing about boats
5-6-96	Mrs. G	Interview with Mrs. G (end of year 1)	Progression of oral discourse components Progression of student participation
5-10-96	Mrs. G	Circle conversation	Air has a color.
5-10-96	Mrs. G	Interview with Mila (Asian girl; high level of oral discourse; high written discourse; high English language use) and Alisha (Asian girl; moderate level of oral discourse; low written discourse; high English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal

Date	Class-room	Type of Interaction	Brief Description
5-17-96	Mrs. G	Interview with Rafiq (Asian boy; low level of oral discourse; moderate written discourse; intermediate English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
5-17-96	Mr. K	Circle conversation	Air has weight.
5-17-96	Mr. K	Interview with Uchenna (African girl; low level of oral discourse; low written discourse; intermediate English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
5-24-96	Mr. K	Circle conversation	Air is in water.
5-24-96	Mr. K	Interview with Evan (Asian boy; high level of oral discourse; moderate written discourse; high English language use)	Activities in science class Ideas in last circle conversation Student participation in circle conversations Description of writing and drawing in journal
5-24-96	Mr. K	Interview with Mrs. G (end of year 1)	Progression of oral discourse components Progression of student participation

Year 2 (1996-97)

Date	Class-room	Type of Interaction	Brief Description
11-12-96	Mrs. G	Whole class discussion Small group work	Drawing animals for habitat murals
11-18-96	Mrs. G	Whole class discussion Small group work	Making and pasting plants for habitat murals
11-18-96	Mr. K	Whole class discussion Small group work	Making and pasting plants for habitat murals
11-19-96	Mrs. G	Teacher introduction Small group work	Working on habitat murals
11-20-96	Mr. K	Teacher introduction Small group work	Working on habitat murals
11-20-96	Mrs. G	Teacher introduction Small group work	Habitat murals
11-21-96	Mr. K	Teacher introduction Small group work	Habitat murals
11-25-96	Mrs. G	Teacher introduction Small group work Individual journal work	Finishing habitat murals
11-25-96	Mr. K	Teacher introduction Small group work Individual journal work	Finishing habitat murals
11-26-96	Mrs. G	Teacher introduction Individual journal work Small group work	Talking and writing about habitat murals
11-27-96	Mr. K	Teacher introduction Small groups share with class.	Oral group reports on habitats
12-3-96	Mrs. G	Teacher introduction Small groups share with class. Individual report writing	Oral group reports on habitats and writing final reports
12-4-96	Mr. K	Teacher introduction Small groups share with class. Individual report writing	Oral group reports on habitats and writing final reports
12-4-96	Mrs. G	Teacher introduction Individual report writing Individual reading	Writing final habitat reports

Date	Class-room	Type of Interaction	Brief Description
12-5-96	Mr. K	Teacher introduction Individual tests Small group review	Living things post-test
12-9-96	Mrs. G	Teacher introduction Individual tests Whole class discussion	Living things post-test State curriculum about senses
12-9-96	Mr. K	Whole class discussion Small group work	State curriculum about senses
12-16-96	Mrs. G	Circle conversation	All animals need plants to live.
12-16-96	Mr. K	Circle conversation	All animals need plants to live.
1-15-97	Mr. K	Circle conversation	Sight is more important than hearing.
1-15-97	Mrs. G	Circle conversation	Sight is more important than hearing.
1-21-97	Mrs. G	Teacher introduction Pair and small group work	Describing matter
1-22-97	Mr. K	Teacher introduction Pair and small group work Whole class discussion	Describing matter
1-29-97	Mr. K	Teacher introduction Small group work Whole class discussion	Exploring properties of matter with clay
1-29-97	Mrs. G	Teacher introduction Small group work Whole class discussion	Properties of matter
1-30-97	Mr. K	Teacher introduction Small group work Whole class discussion	Properties of matter
2-3-97	Mr. K	Teacher introduction Small group work Whole class discussion	Properties of liquid and solid lemonade
2-4-97	Mrs. G	Teacher introduction Individual journal work Teacher demonstration	Solids, liquids, gases and evaporation
2-5-97	Mr. K	Teacher introduction Individual journal work Teacher demonstration	Solids, liquids, gases and evaporation
2-5-97	Mrs. G	Teacher introduction and demonstration Individual journal work	Condensation

Date	Class-room	Type of Interaction	Brief Description
2-6-97	Mr. K	Teacher introduction and demonstration Individual journal work	Condensation
2-7-97	Mrs. G and Mr. K	Interview with Mrs. G and Mr. K (middle of year 2)	Strategies for introducing the oral discourse components Goals for small group investigations and journal writing
2-10-97	Mrs. G	Teacher introduction and modeling Small group work	Reviewing matter
2-10-97	Mr. K	Teacher introduction and modeling Small group work	Reviewing matter
2-11-97	Mrs. G	Teacher introduction Small group work Small groups share with class.	Matter group reports
2-11-97	Mr. K	2 nd Interview with Evan (Asian boy; high level of oral discourse; moderate written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-12-97	Mrs. G	Whole class discussion Individual tests	Matter post-test
2-12-97	Mr. K	Teacher introduction Small group work Small groups share with class.	Matter group reports
2-12-97	Mrs. G	Interview with Rebecca (Asian girl; high level of oral discourse; high written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-12-97	Mrs. G	Interview with Kirk (European American boy; moderate level of oral discourse; low written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used

Date	Class-room	Type of Interaction	Brief Description
2-13-97	Mr. K	Whole class discussion Individual tests	Matter post-test
2-18-97	Mr. K	Interview with Natalie (European American girl; high level of oral discourse; high written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-19-97	Mrs. G	Interview with Shin-II (Asian boy; moderate level of oral discourse; moderate written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-19-97 2-26-97	Mrs. G	2 nd Interview with Preston (Asian boy; high level of oral discourse; high written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-20-97	Mr. K	Interview with Sang-Ook (Asian boy; high level of oral discourse; moderate written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-25-97	Mr. K	Interview with Joey (Asian boy; low level of oral discourse; moderate written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-25-97	Mr. K	Interview with Jae-Hwa (Asian girl; low level of oral discourse; moderate written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used

Date	Class-room	Type of Interaction	Brief Description
2-26-97	Mrs. G	Interview with Janice (African American girl; low level of oral discourse; high written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
2-27-97	Mr. K	Interview with Arshad (Asian boy; moderate level of oral discourse; moderate written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
4-2-97	Mr. K	Teacher introduction Ray reads cloud story. Whole class and small group demonstrations Individual chart writing	Making a cloud
4-3-97	Mrs. G	Teacher introduction Whole class and small group demonstrations Ray reads cloud story. Individual chart writing	Making a cloud
4-3-97	Mr. K	Interview with Young-Jae (Asian boy; low level of oral discourse; moderate written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
4-14-97	Mrs. G	Circle conversation Whole class discussion Individual worksheets	Volcanoes can change the weather. Thermometers
4-14-97	Mr. K	Circle conversation Whole class discussion Individual worksheets	Volcanoes can change the weather. Thermometers
4-15-97	Mrs. G	Teacher introduction Individual and small group work Individuals share writing with class.	Recording weather data

Date	Class-room	Type of Interaction	Brief Description
4-15-97	Mr. K	Interview with Xiaoping (Asian boy; low level of oral discourse; low written discourse; beginning English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
4-16-97	Mr. K	Teacher introduction Individual and small group work Whole class discussion	Measuring different temperatures
4-16-97	Mrs. G	Teacher introduction Individual and small group work Whole class discussion	Measuring different temperatures
4-17-97	Mr. K	Teacher introduction Individual and small group work Individual journal work	Temperature worksheets and weather journals
4-18-97	Mr. K	Interview with Alan (European American boy; high level of oral discourse; moderate written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
4-21-97	Mrs. G	Whole class reads story. Teacher demonstrations Whole class discussion Individual journal work	Hot and cold air
4-21-97	Mr. K	Teacher demonstrations Whole class discussion Individual journal work	Hot and cold air
4-22-97	Mrs. G	Teacher review Whole class discussion Individual journal work	Hot air and weather data
4-22-97	Mr. K	Interview with Jennifer (Asian girl; moderate level of oral discourse; moderate written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used

Date	Class-room	Type of Interaction	Brief Description
4-23-97	Mr. K	Teacher introduction Individual and small group work Individual journal work Individual tests	Moving air Weather post-test
4-23-97	Mrs. G	Teacher introduction Individual and small group work Individual journal work Individual tests	Moving air Weather post-test
4-30-97	Mrs. G	Individual and small group work	Making water collages
5-1-97	Mr. K	Individual and small group work Whole class discussion	Making water collages Water (KWL)
5-1-97	Mr. K	Interview with Jill (African girl; high level of oral discourse; high written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-5-97	Mrs. G	Teacher introduction and story Teacher modeling Small group work	Describing objects
5-5-97	Mr. K	Teacher introduction and story Teacher modeling Small group work	Describing objects
5-7-97	Mr. K	Teacher introduction and modeling Small group work Circle conversation	Floating and sinking predictions What material would you use on the bottom of the boat?
5-7-97	Mrs. G	Teacher introduction and modeling Circle conversation Small group work Individual journal work	Floating and sinking predictions What material would you use on the bottom of the boat? Floating and sinking predictions

Date	Class-room	Type of Interaction	Brief Description
5-8-97	Mrs. G	Interview with Katie (European American girl; low level of oral discourse; moderate written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-12-97	Mrs. G	Teacher introduction Small group work Individual journal work	Testing materials for floating and sinking
5-12-97	Mr. K	Teacher introduction Small group work Individual journal work	Testing materials for floating and sinking
5-13-97	Mr. K	Interview with Mariana (Latin American girl; moderate level of oral discourse; low written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-14-97	Mr. K and Mrs. G	Interview with Mr. K and Mrs. G (end of year 2)	Progression and changes in oral discourse Influence of gender and culture on student learning in science
5-15-97	Mr. K	Circle conversation	For a boat, would you want something that absorbs?
5-19-97	Mrs. G	Teacher role play Student questions	Learning about boats from different cultures
5-19-97	Mr. K	Teacher role play Student questions Student role play	Learning about boats from different cultures
5-20-97	Mr. K	Interview with Brent (European American boy; low level of oral discourse; low written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-20-97	Mrs. G	Teacher introduction Individuals share stories with class.	Student boat stories

Date	Class-room	Type of Interaction	Brief Description
5-21-97	Mr. K	Teacher introduction Individuals share stories with class. Individual writing and drawing	Student boat stories
5-21-97	Mrs. G	Whole class discussion Mrs. G reads story. Individual and small group work	Constructing toy boats
5-21-97	Mrs. G	Interview with Hyun-Shik (Asian boy; high level of oral discourse; high written discourse; high English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-21-97	Mrs. G	Interview with Yazid (African boy; low level of oral discourse; low written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-22-97	Mr. K	Teacher introduction Individual and small group work	Constructing toy boats
5-27-97	Mrs. G	Teacher introduction Individual and small group work	Testing toy boats
5-27-97	Mr. K	Interview with Alexandra (European American girl; high level of oral discourse; moderate written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-28-97	Mr. K	Teacher introduction Individual and small group work	Testing toy boats
5-28-97	Mrs. G	Individual journal work	Writing about toy boats

Date	Class-room	Type of Interaction	Brief Description
5-28-97	Mrs. G	Interview with Purnima (Asian girl; low level of oral discourse; moderate written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-28-97	Mrs. G	Interview with Craig (European American boy; low level of oral discourse; low written discourse; native English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-29-97	Mrs. G	Interview with Young-Nam (Asian boy; low level of oral discourse; low written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used
5-29-97	Mr. K	Interview with Fareed (Asian boy; low level of oral discourse; low written discourse; intermediate English language use)	Year 1 interview questions Students' perceptions of science in and out of school Role of talk in science interactions How oral discourse components were used

Shading:

	Classroom interactions
	Student interviews
	Teacher interviews

APPENDIX B

Student Interview Protocol Year 1 (1995-96)

Science

1. What kinds of things do you do in science?
(e.g., Friday talks, investigations, journals, whole class discussions)
2. Tell me what happens when your class talks about science on Fridays.
3. What were you discussing in last Friday's talk?
4. What did you learn about _____ (science topic)?
5. What was your idea about _____ (science topic)?
6. Did your idea change at all in the discussion?
7. Do you still have some things you are wondering about _____ (science topic)?
If so, what are they?

Conversation Participation

8. Who talks in the Friday science conversations?
9. What do they say?
10. Do you talk? If so, what do you say?
11. How do students get picked to talk?
12. How do you decide whom to call on after you have spoken?
13. Is it easier to talk on Fridays with everyone or during the week when you are working on an investigation or writing in your journal? Why do you think that is?

Journals

14. Tell me what you write about in your science journals.
15. Do you work on journals alone or with other students?
16. Tell me about this page in your journal (page with conversational elements).
17. Is there anything else you would like to talk about?

**Student Interview Protocol
Year 2 (1996-97)**

Science

1. When you hear the word *science*, what do you think of?
2. Who does science? Who could do science? Do kids do science? Can anyone do science? Do you do science?
3. What kinds of things do you do in science in your classroom?
4. What have you been studying in science lately?
5. Do you remember what you knew about _____ (science topic) when you started learning about it this year in school?
6. What new things have you learned about _____ (science topic)?
7. Do you still have some things you are wondering about _____ (science topic)? If so, what are they?
8. How do you feel about the things you have been doing in science in school?
9. What do you like best about that? least?
10. Who do you learn science from in school? Do you ever teach anyone about science?
11. Do you ever do science out of school, e.g. at home, with friends, etc.?
12. How do you feel about it? What do you like best about that? least?
13. Who do you learn science from out of school? Do you ever learn science from scientists? Do you ever teach anyone about science out of school?
14. How did you learn about science in your last school (home country)?
15. If someone asked you, "What is science?" what would you say?
16. Would you like to become a scientist when you are older? Could you be a scientist if you wanted to? Why or why not?
17. What do scientists do?

Conversation Participation

18. Sometimes you work at a table with other students on science investigations. Who do you work with? Who decides whom you will work with?
19. Do you talk to other students when you are working on a science investigation? What do you say? What do they say?
20. Does it help you learn science better when you talk about it? How does it help you? If not, what does help you?
21. Sometimes you also sit in a circle and talk about science. Can you tell me about that?
22. What do people talk about?
23. How do students get picked to talk?
24. How do you decide whom to call on after you have spoken?
25. Is it easier to talk during circle talks with everyone or during the week when you are working on an investigation or writing in your journal? Why do you think that is?
26. Are there ever times when it is hard to talk about science? When are they?
27. Are there ever times you would rather work alone in science rather than with other students?
28. Does *agreeing* and *disagreeing* help you talk about science? Does *giving a reason* help you talk about science? Does *encouraging* help you? Why is that?
29. Do you agree and disagree when you are doing science investigations or working in your journal?

Journals

30. Tell me what you write or draw about in your science journals.
31. Do you work on journals alone or with other students?
32. Tell me about a page in your journal. Did you work on it alone or with other students?
33. How do science journals help you learn about science?
34. Is there anything else you would like to tell me about your learning?

APPENDIX C

Teacher Interview Protocol Beginning of Year 1 (1995-96)

Literacy Components (later referred to as Oral Discourse Components)

1. What literacy components are you working on now?
2. Why are these components important in your classroom?
3. What functions(s) do the literacy components serve in teaching/learning science?
4. What instructional strategies are you using to introduce and familiarize students with the components?
5. Where do you perceive students to be in their use of the literacy components at this time?
6. How do you assess that students are using literacy components proficiently?
7. How do you see the literacy components unfolding throughout the year? (What does your yearly plan look like?) Why have you chosen this order to introduce components?

Inclusion

8. How do you help students to follow and make sense of the conversation?
9. Who is included and not included in scientific discussions?
10. How does student diversity affect your science conversations?
11. How do you try to develop and maintain equity and community in the discussions?
12. What do you do when students do not participate or dominate in oral discussions?
13. Do you see changes in student participation (inclusion) over time? What are they? [Next interview: What changes have you seen in student participation?]

Dissonance

14. Are disagreements among children ever combative? If so, how are they handled?

15. How and when are scientific claims or concepts presented to the class?
16. Do students ever feel hurt or resistant if their claims do not match the scientific claims, or their responses do not fit the task? If so, how is this handled?
17. Are there other kinds of things that happen that you think make students wary or hesitant to participate?

Collaboration

18. Tell me a little about your collaboration with Mrs. G (Mr. K)?
19. What benefits do you and the students receive from your teaching collaboration?
20. Is there anything else you would like to comment on?

**Teacher Interview Protocol
Middle of Year 1 (1995-96)**

Literacy Components (later referred to as Oral Discourse Components)

1. What literacy components are you working on now?
2. What has been the progression in literacy components since the beginning of the year?
3. Where do you perceive students to be in their use of the literacy components at this time?
4. How do you connect the literacy components from the Friday discussions to science instruction (whole class, small group or journal work) during the rest of the week?
5. Are there things that you are noticing that go outside the literacy components which are important to the Friday conversations?
6. Where do the Friday questions or statements for discussion come from?
7. How do you think things are going with some of the strategies you have introduced?
 - a. at times using problems for students to solve instead of statements
 - b. students calling on each other
 - c. your taking of notes
8. What do you see as your role in the Friday science conversations?

Participation

9. What changes have you seen in student participation since the beginning of the year?
10. Are there particular students who come to mind when you think of changes in participation?
11. Do you have concerns about certain students talking too much or too little?
12. How does student participation in Friday sessions compare to science investigations and journal writing during the week?
13. Do students participate more or less in different contexts, e.g. Friday talks, whole class discussions, science investigations, working on journals? Why do you think that is?

Overall

14. What is your overall sense of how the Friday sessions are going?
15. Is there anything else you would like to comment on?

Teacher Interview Protocol
End of Year 1 (1995-96)

Literacy Components (later referred to as Oral Discourse Components)

1. What literacy components are you working on now?
2. What has been the progression in literacy components since the space unit (taught in the middle of the school year)?
3. Where do you perceive students to be in their use of the literacy components at this time?
4. Are there things that you are noticing that go outside the literacy components which are important to the Friday conversations?
5. Have you introduced new strategies recently? How do you think things are going with them?
6. Has your role changed in the Friday science conversations?

Participation

7. What changes have you seen in student participation since the beginning of the year?
8. Are there particular students who come to mind when you think of changes in participation?
9. Have you noticed any patterns in their choices of who to call on? How do you think that procedure is working?
10. Has there been anything new in student participation in Friday sessions compared to science investigations and journal writing during the week?

Overall

11. Is there anything else you would like to comment on?

**Teacher Interview Protocol
Middle of Year 2 (1996-97)**

Oral Discourse

1. How do you introduce the *agree*, *disagree*, and *giving reasons* moves to the students at the beginning of the year in the science talks?
2. Would you give an overview of oral discourse in science this year?

Small Group Investigations

3. Would you discuss briefly your science goals, discourse goals and community goals for students in small group science investigations?
4. How are the students organized for small group science investigations?

Journal Writing

5. Would you discuss briefly your science goals, discourse goals and community goals for science journal writing?
6. How does science journal writing complement oral discourse?

Teacher Interview Protocol
End of Year 2 (1996-97)

Oral Discourse

1. Would you give a brief summary of oral discourse in science this year?
2. Have you made any changes in oral discourse over the year, and how did they go?
(e.g., making gender of turns explicit)

Roles of Culture and Gender

3. What roles do you see culture and gender having in your science instruction and the students' learning?

Overall

4. How is it working doing the science conversations in your classrooms?

APPENDIX D

Transcription Conventions (adapted from Dressler and Kreuz, 2000)

<u>Symbol</u>	<u>Meaning</u>
?	rising intonation
.	falling intonation
,	continuing intonation
[	overlapping speech
TEXT	spoken loudly
(text)	transcriber's comments

APPENDIX E

Expanded List of Narrative and Paradigmatic Features for Language Analysis

Features of Narrative Language

1. Construction of two landscapes (Bruner, 1986)*
 - a. Landscape of action (story grammar)
 - 1) May contain story elements and plot (sequence: beginning, middle, end)
 - 2) Theme, “valued endpoint”
 - 3) Use of literary features such as simile, metaphor, hyperbole
 - b. Landscape of consciousness (knowing, thinking, feeling)
 - 1) Psychic reality
 - 2) Personal, based on personal experience (Teacher’s observations of students’ talk)
 - 3) Use of *subjectification*; the depiction of reality not through an omniscient eye that views a timeless reality, but through the filter of the consciousness of protagonists in the story
 - 4) Use of *presupposition*, the creation of implicit rather than explicit meanings. For with explicitness, the reader’s degrees of interpretive freedom are annulled.
 - 5) Use of *multiple perspective*: “beholding the world not univocally but simultaneously through a set of prisms each of which catches some part of it” (Bruner, 1986)
 - 6) Evaluator: commentator on significant life experiences, express feelings about a topic (Dyson & Genishi, 1994)
 - 7) Social Actor (Dyson & Genishi, 1994)
 - a) To engage others in classroom dialogue, interweave individual lives (community)
 - b) Expression of subjective self (culture, gender, class, etc.)
 - 8) Concern for human condition, human intentions (Bruner, 1986)
2. Purpose to make experience comprehensible (Bruner, 1986)
 - a. Believable, not testable
 - b. Lifelikeness, probability, particular connections, meaning of experience
 - c. Particular experiences
3. Word choice dependent on protagonist, subjective landscape and action (Bruner, 1986)
4. Inseparability of character, setting and action (Bruner, 1986)
5. Spectrum of possible meanings (Bruner, 1986)

Features of Paradigmatic Language

1. Layouts of arguments (Toulmin, 1958)
 - a. Arguments have formal, sequential structure
 - b. Variety of argument forms
 - c. Consists of propositions and formal relations
 - d. Phases of an argument
 - 1) Present problem
 - 2) Survey possible solutions and then ordering probable solutions
 - e. Parts of an argument
 - 1) Data (D)
 - 2) Qualifier (Q)
 - 3) Claim (C)
 - 4) Warrant (W)
 - 5) Rebuttal (R)
 - 6) Backing (B)
 - 7) Force (practical implications of a term)
 - 8) Criteria (standards, grounds and reasons to decide appropriateness of a term)
 - f. Categorization, conceptualization, formal operations, general propositions, testable, consistency, noncontradiction, defined by observables to which basic statement relate, driven by principled hypotheses
 - g. Good theory, tight analysis, logical proof, sound argument, and empirical discovery guided by reasoned hypothesis, imagination leads to formal connections
2. Purpose is justificatory; primary function of arguments to support assertions (Bruner, 1986)
3. Word choice dependent on clear, definite reference and literal sense; technically correct, factual language (Bruner, 1986)
4. Testable, verifiable (Bruner, 1986)
 - a. Conclusive or not
 - b. Sound arguments stand up to criticism
5. Abstract, impersonal (Bruner, 1986)
6. Assertions are serious (Toulmin, 1958)
7. Use of analogies (Student talk)

*Source of features in parentheses following feature

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