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"IT JUST FLIES": JOINT CONSTRUCTION OF ACCOUNTS IN ELEMENTARY SCIENCE CLASSROOMS

By

Mark Enfield

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ABSTRACT

"IT JUST FLIES": JOINT CONSTRUCTION OF ACCOUNTS IN ELEMENTARY SCIENCE CLASSROOMS

By

Mark Enfield

Increasingly elementary classrooms use whole group discussions to help students make sense of ideas; this includes science teaching and learning. Science teaching and learning faces particular problems in this practice. We know that students hold naïve conceptions of phenomena that challenge development of understandings of science ideas. Students in whole group sense making discussions naturally introduce naïve conceptions. Therefore one question asks whether this practice facilitates students' making sense of phenomena, challenging students' naïve conceptions, and learning scientific ideas. In addition, the social and linguistic demands of discussions privilege students who tacitly understand the logic of scientific discourse, who have greater command of language, and who have higher social status in the class. The goal is that students will collaboratively construct accounts that make sense of phenomena in the natural world; but this is not easy. Patterns in video-recorded discussions show that students' interests lay in jointly constructing accounts that describe how to control phenomena. Such accounts sound like descriptions of how to do things to achieve certain outcomes. When discussions attempt to generate this kind of account, more students participate and there is increased use of shared utterances. However, science also attempts to generate accounts that describe and explain phenomena free from human action. In this

study, when the teacher (also this researcher) attempts to shift students' towards accounts that describe phenomena free of human intervention, problems arise. Students make fewer attempts to speak or share utterances. Furthermore, the discussions become triadic, involving only the teacher and one or two students. Thus I argue that to support students' collaboration they need opportunities to pursue accounts that are meaningful and useful to them. In addition, to learn scientific modes of communication, instruction needs to include careful and deliberate actions that help students learn to construct scientific accounts. To help young students learn language and how to use language, while simultaneously learning science, places heavy demands on classroom teachers. Teachers need support to facilitate learning language, ideas, practices, and how to jointly construct accounts of phenomena that are meaningful to students and also scientific accounts of phenomena in the world.

Acknowledgements

Thoreau writes that he went to Walden Pond so that he might live life deliberately. The problem is that we all know that living deliberately involves more than the statement implies. It involves people providing opportunities, being knowledgeable, and serving as sources encouragement to continue a deliberate life. While Thoreau describes some people he encountered in his life on Walden Pond, I suspect those people did more than his writings convey.

As I think about my opportunity to deliberately investigate how young students learn science, it is clear that my work was as much about understanding how young students learn science as it was about learning to work with and rely on others. Thus before diving into theories, data, explanations, and explorations described in this dissertation, I want to pause to express my gratitude to those who helped me live deliberately in one classroom with a group of students.

To begin with the regular classroom teacher and the students in the classroom deserve thanks. For me, Deborah Corbin became another hero of teaching when she allowed me to join her classroom as a teacher. For two years I was fortunate to watch and learn from her and other teachers what it means to be an excellent teacher. She allowed me to alter curriculum, try different ideas, and explore the various ways that students could learn science through talking about their ideas. Those students also deserve my thanks. They worked, thought, struggled, laughed, and learned many things. Throughout it all they were open to my constantly asking them to talk to one another and let me listen to their ideas as a way of helping them learn science.

Helping me learn to see things in classroom events and pushing me to develop deeper understandings of my experiences were my committee members. They deliberately pushed me to be clearer about my questions, connect my ideas with my data, and understand based on evidence how events in the classroom made sense. Charles (Andy) Anderson spent more than three years listening to me talk about data, providing me with ways to look at events in this classroom, and helping me understand ways that my students were making sense of science. He, along with others, Jenny Denyer, Victoria Purcell Gates, and Edward Smith, guided and supported me through a mountain of videotapes, my ever expanding and entangled questions, and my struggles to explain the things that I saw.

Finally I had wonderful encouragement throughout this process. My family and friends continue being thoughtful, encouraging, and supportive from the moment I left Oklahoma to come to Michigan State University until the moment I submit this dissertation. But words alone will never explain the ways that my wife, Leigh Hall, stood by me through the brightest and darkest times. She encouraged me, supported me, and listened while I rambled on about my most recent finding in the data. She not only allowed me to stay up all hours of the night, work tireless days, and still smile as I groaned; she also continued to have unending confidence in my ability. I do not know which of these things she did deliberately. However, it allowed me to live deliberately in my data. For that I will be forever grateful.

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Chapter 1

INTRODUCTION: JOINT CONSTRUCTION IN ELEMENTARY SCIENCE DISCUSSIONS

Introduction

This study examines the development of students' sense-making in elementary science classrooms. My interests, based on my personal history and teaching experiences, are in the ways that talk in social settings supports the sense-making around science ideas, focusing on two issues. First, one way to make sense of science involves developing accounts for experiences with phenomena in the world. Second, scientific accounts of those phenomena involve particular ways of reporting, considering, and explaining experiences with phenomena in the world. Students often account for phenomena in ways that are ultimately not scientific. Thus an important question is; how do students (and teachers) collaborate on explanations of phenomena in the world? What is the nature of claims that students make in discussions that supports collaboration around the construction of accounts of phenomena? Based students' joint construction, what is the nature of the accounts that young students find meaningful and useful? Finally considering the nature of the accounts that students jointly construct, how do those accounts compare to the goals and norms of science in the context of whole group discussions?

This study reports data collected from my work as a classroom teacher and thus follows a participant observer perspective (Atkinson & Hammersly, 1994). The questions above arose based on my experiences learning and teaching science. Those question rest on some fundamental assumptions. First, an effective means of developing accounts of phenomena in the world relies on collaborative, social activity intended to serve a joint purpose. Second, the accounts developed can be thought of as scientific if they include descriptions of experiences and observations of phenomena, patterns in those experiences and observations, and ultimately explaining those patterns. Ultimately a goal of science teaching and learning would be to develop scientific accounts. However, the joint purposes of participants in social activity in a classroom may not always lead to the stated goal of science learning. However, before getting to the interactions and potential outcomes of collaborative activity, it is important understand things about my learning and teaching of science, the origins of these questions, and the connections I think are important to science teaching.

What are the origins of this question? – My background

My interest science goes back as long as I can remember. Unfortunately, I don't remember learning science in elementary school. I do remember following my father, a research scientist, as he collected and described observations of phenomena in the world, and reported his findings at conferences and in papers. Dad always had detailed explanations of the work he was doing and reasons why it made sense and was important. At home, Mom encouraged us to explore the world around us, tell about our experiences, and

explain our ideas why those experiences made sense. We often sat after dinner talking about our experiences from the day and explaining our theories of the world while our parents listened. Whether we espoused a theory about the world or asked for candy at the grocery store, my parents constantly pushed us to explain why we thought the things we thought. Through this social activity of explaining the reasons why we thought or wanted things, we learned that causes were important to explanations. Furthermore we learned that depending on the context and theory certain reasons made more useful explanations than other reasons. These early years socialized me into scientific reasoning.

My background of learning to think about reasons naturally led me as an undergraduate to pursue a degree in science. During my first semester in college I took a Physics course. As I reflect on early formal experiences learning science, a common thread was that the experiences I recall involved social encounters where I worked with others to develop accounts of phenomena that were meaningful and useful in the given context. Specifically I am thinking of laboratory activities working to explain the phenomena we observed. For me, learning science was a discursive activity involving interactions with other people.

When I began graduate studies in Physics, I was surprised to find that one of the top physicists at that university had a small lab in which he worked alone. Furthermore, Industrial and Applied Physics seemed less than applied and did not really involve explaining phenomena of the world[1]. The highlight of this time was working as a lab instructor and tutor in the physics department. I loved

[1] These were my impressions and may be far from the truth. All I know is that I can still recall the small, dimly lit room called the lab, my coursework that was primarily mathematical derivations of equations, and limited social contact with others.

helping other people understand the elegance of explanations that accounted for so many of the varied phenomena in the world. It quickly became apparent that graduate study in Physics was not a good career choice for me.

I was fortunate to find a position in a hands-on science museum. The interactive exhibits and hands-on science classes offered rich in opportunities to engage others in collaboratively developing accounts of phenomena. Whether teaching a class or discussing an exhibit with a visitor, interactions with visitors required listening and hearing the ways people interpreted the phenomenon an exhibit attempted to demonstrate. These interactions also required thinking about how different interpretations made sense. The ultimate goal was to help visitors understand scientific accounts of the phenomena they witnessed.

But something about this experience was not satisfying. One problem was that the museum offered flashy and extravagant phenomena that were engaging, but not very common to visitors' everyday experiences. Another problem was that there was something missing in these experiences. I wondered how they impacted people and their lives, did their experience at the museum change the way they interpreted phenomena in the world? I had many experiences feeling that the kinds of explanations I helped visitors understand were not wholly satisfying to them. Based on this, I was dissatisfied with interactions with visitors because I felt that they left the museum with non-scientific accounts, but with the impression that their accounts were scientifically accurate.

I began doctoral studies in science education hoping to find answers to these problems of science learning. A wise faculty member, who later became

my advisor and dissertation director, suggested that my limited experience in schools (having only completed a practicum experience) inhibited the range of questions that I might ask of teaching and learning science. Therefore I sought out opportunities to teach science in elementary schools. It was through classroom teaching and a mini-study conducted during those experiences that the questions of this study emerged. Working in a classroom with students and listening to them explain phenomena helped me realize that there were yet unexplored benefits and drawbacks in whole group discussions of science experiments and concepts. This study focused on such benefits and drawbacks.

Focusing the work

In the following section I describe thinking that led to the central research question: how does one multi-age group of first to third grade students engaged in whole group discussions use language to jointly construct (collaborate on) accounts of phenomena in the world? This central question has led me to sub-questions about participation, language, and content. These questions are as follows:

1. How can students' participation in joint construction of accounts be described in terms of claims and accounts?
2. How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?

3. What is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

It is important to note that while I will treat these classifications separately, the central question implies overlaps of these classifications.

Participation: How can students' participation in joint construction of accounts be described in terms of claims and accounts?

A central goal of the current reform of science education is that this is an educational reform about all students learning science with understanding (National Research Council, 1996; Rutherford & Ahlgren, 1989). Keeping in mind this study's question about oral language and focusing on *all students learning science with understanding*, requires considering many different issues. The issue most relevant to this study is the inclusion of linguistically and culturally diverse students in discourses[2] of science (Lee & Fradd, 1996, 1998). Discourses refer to the linguistic practices and processes that distinguish members of a community (Gee, 1991, 1997). One approach that strives toward this goal is to think about how students should learn the linguistic practices and processes of science. A different approach would be to attempt to ensure the participation of students of all cultural and linguistic backgrounds in the context of whole group discussions in science classrooms. Regardless of the approach, to ensure all students learn science with understanding, an important consideration

[2] This study uses the term discourse in particular ways to mean ways of using language to participate in communities. Portions of this will be addressed in the following section about language.

when implementing discourse oriented pedagogies will be to think about students' participation.

Memories of students I have taught often involve their participation in various contexts. I remember thinking in the science museum about the ways different students worked together on projects, listening and talking with one another. One of the primary responsibilities that I had while working at the museum involved coordinating a program for middle school students called, "If I Had a Hammer." In this program students worked in groups to build a house using drills and screws in a two hour session. After teaching the same lesson hundreds (yes literally hundreds) of times I began to pay attention to how groups worked together. Some focused on equitable participation of all, some invoked principles of division of labor, and still others seemed to be groups of independent operators. It was clear that students had many different ways of participating with one another. The adults chaperoning the students often wanted to dictate over this participation. But I learned there were many benefits to various forms of participation and that autonomic construction led to task completion, but not to learning how to work together, or make sense of diverse approaches to ideas and problems.

Informal learning environments present special problems of participation. The question remains whether such problems carry over to discussions in classrooms; my experience says it does. One story comes from my teaching in a third grade classroom and involves a student who I will call Carlos. Carlos actively listened and attempted to contribute to the discussions. However, Carlos

faced a couple of barriers. First, he had speech problems that made his oral language difficult to understand. Furthermore, the fact that he stuttered and re-started several times in his turns made it even more difficult to understand him. Carlos infrequently spoke and if he did it seemed to me that his ideas failed to become topics in the discussion. In fact, later analysis of data from those discussions[3] revealed that Carlos often had relevant and important ideas to include in the discussion. Furthermore, his ideas did become topics in the discussion, but he did not get credit for making those contributions. In summary, Carlos attempted to participate with the group, but the group did not actively participate with him.

This issue of participation is both a student and teacher issue. In the case of Carlos, students needed to learn to listen to and participate with him. But the teacher in this case held a greater responsibility. I needed to establish contexts and cultures that not only encouraged, but demanded fair participation. I needed to work harder to include Carlos in the discussion. Each of these things should be part of best practice teaching. Yet, there is a lot to learn before we can develop teaching practices. We need better understandings of the language that young students use in discursive contexts. Additionally, we need understandings of the nature of the claims that students make about phenomena through their discourse. Finally we need more complete understandings of students' participation in discursive contexts. These last two understandings introduce *language* and *content*, as being connected to participation. The fundamental

[3] This paper is in preparation, soon to be sent out for review.

assumption that there are interconnected issues in discursive contexts makes it important to also consider them as they relate to participation.

Language: How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?

My first graduate student appointment was on a research project that worked with a teacher study group situated in one school. These teachers were actively involved in exploring the work of Karen Gallas (1995). The teachers worked to include the kind of "Science talk" that engages students in developing theories (or accounts) of phenomena in the world (Gallas, 1995). It was exciting to visit these classrooms, listening to students discuss their theories of how things worked in the world. I noticed how students talked to one another, who spoke and how ideas developed and were part of the discussions that took place in these classrooms. I also listened to the teachers plan, consider and think about the talk and work of their students' science learning. To me, there were exciting things taking place in these classrooms, but I wasn't quite sure what made these things exciting. At the same time, I worried about the complexity of the classroom events I witnessed and felt that there were many things happening that needed some further exploration. Specifically I wondered about the explanations that students came up with, the accuracy of those explanations, and the instances that students generated explanations that were not scientific but remained compelling.

The following academic year I began teaching science in an urban elementary school. My experiences teaching led to a number of questions about the Science Talks that I initiated in my teaching. As a white middle class male, with a strong scientific background, I knew based on reading Heath (1983) that my 'ways with words' were probably quite different from those of my students. These different 'ways with words' are important resources that people use to make sense of the world around them. Students' 'ways with words' present two problems for classroom discussion; first, students' linguistic differences may make sense-making and meaning-making challenging in classroom settings. Second, students need to learn to participate and communicate using academic discourses. Therefore there is a need to help students learn new ways of speaking in order to be successful in school.

I interpreted success as developing what Gee (1991) describes as a secondary discourse in science. I wanted students to be successful using language structures privileged in school and especially in science learning. I wondered whether the Science Talks helped students learn the discourse of school science. During that year I completed a study that examined the role of my content knowledge as a mediating factor in helping students gain access to and participate in Science Talks (Enfield, 2000a, 2000b).

Reflecting on the first year of looking at discussions in classrooms using the conceptual lenses I had, resulted in my feeling less than satisfied with the result. The problem was that as I worked with students and listened to them in Science Talks, I felt that my normative expectations of developing students'

secondary discourse prevented me from hearing and understanding their sense-making. I began thinking about Bakhtin's {, 1896 #106} dialogic problem that thoughts are shaped through interactions with others. This complemented with the Vygtoskian (1986) notion of thought and language suggested that I needed to think more about the language that my students were using in these discussions. I needed to consider the students' meanings in Science Talks as much as I needed to think about their 'ways with words.'

Originally a problem was that my treatment of language assumed singular meanings of students' utterances. This one to one correlation I attempted to make between statement and meaning treated language, utterances, and meaning as empirical constructs. However, Quine's (1953) dismissal of empiricism revolutionized my thinking about knowledge in the world, and thus my empirical treatment of language left me feeling dissatisfied. But I struggled to connect this to students' language. It was not until I began to understand the Bakhtinian (1986) notion that no utterance has singular meaning and therefore cannot be adequately examined based on meaning alone. Quine's (1953) major criticism was the problem of synonymy and Bakhtin suggests that in language no two utterances have synonymous meanings. Therefore I needed to consider the polysemous meanings of students' utterances.

Attempting to resolve this problem I turned to different perspectives on language. Specifically, I considered the forms and functions of language of students' oral language. This functional approach to examining students utterances followed work of Coulthard (1985) and Grice (1999) to consider how

forms of students' language functioned in discourse contexts to communicate ideas about the world. An important idea from functional analysis of language is that statements or utterances in a discussion require some relationship to preceding statements. Thus describing the nature of students' utterances in discussion and looking for patterns in those utterances is important. This lead to the ultimate articulation of the question: How do forms of language students use in oral discussions function to facilitate joint construction of accounts of phenomena?

Content: What is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

My concerns over students sense-making in science is actually the prelude to the story contained in this study. My interest in pursuing a doctorate in science education stems from discontent that I felt while working in the science museum. At that time I had been introduced to conceptual change theories as they relate to science learning (Posner, Strike, Hewson, & Gertzog, 1982; Smith, 1990). But it was not clear, especially in the context of the hands-on museum, how such theories could be useful in teaching science. However, it was clear, based on interactions with museum visitors, that everyone has different accounts of phenomena and ways of making sense of phenomena. I prefer to think of the accounts and sense-making strategies as naïve accounts (Shapiro, 1994) that do not fully reflect the knowledge and practice of science.

The notion that individuals hold naïve ideas about the way the world works was actually one problem I encountered while working in the museum. Many of the exhibits presented phenomena, but did not challenge visitors' ways of explaining or making sense of phenomena. One exhibit stands out in this regard. The coupled pendulum consisted of two simple pendulums, suspended at equal lengths, connected by a stiff bar about two-thirds of the distance from the bottom of the cable suspending the weights. If operated properly, the coupled pendulum was a dramatic demonstration of conservation of energy. However, often visitors would push the pendulum bobs to see the result, and explain it just as they would any simple pendulum. While they engaged with the phenomenon, their ideas remained unchanged.

But if I stood at the exhibit and engaged people in discussions about why they thought different things happened, the experience was dramatically different. At times people were almost disturbed by the result and then began exploring the exhibit with more deliberate actions to develop deeper understandings. These experiences introduced me to the power of prior conceptions and encouraged me to think about the importance of those discussions in challenging conceptions. This raises a question; what sources of knowledge contribute to an individual's accounts of phenomena?

Leaving the museum and entering the world of academia, it was possible to begin to explore and more fully realize the potential of conceptual change theories (Posner et al., 1982; Smith, 1990). The theory helped situate science learning in terms of the experiences and sources of knowledge a learner has with

phenomena in the world. These experiences are the foundation of ideas and explanations of those phenomena. The theory also suggests ways to engage learners in thinking about their explanations to help develop more scientific explanations of those phenomena. Further it became clear that learning is a dialogic act (Bakhtin, 1986) that involves interactions between learners, teachers, experiences, and explanations.

Realizing that there were important interactions necessary to learning and that whole class discussion in science was an appealing pedagogical strategy, I became interested in thinking about how this functioned in classrooms. Within the context of whole class discussions I became interested in students' understandings and sense-making. This interest was clarified when I began teaching in a classroom, attempting to discussion with a group of students, and facing new challenges.

I recall an experience during a discussion about force and motion that highlighted for me the challenges that a discursive pedagogy faces in helping students make sense of science. We were approaching the end of a study of force and friction. Students sat in a circle, taking turns sharing ideas about forces and friction. Normally, I did not enter conversations other than to clarify points and maintain order. However, on this day, when the circle came to my position, the girl next to me invited me to say something. Making a pedagogical choice[4] to pose a question, I asked students to explain their understanding of the

[4] By this I mean that I chose to say something to challenge students and push them to further their explanations. In other words I was playing a role of teacher to attempt to further student thinking.

connection between force and friction. When I posed this question, the same girl asked, "Don't *you* understand the connection between force and friction?"

There are many ways to interpret this episode. Important to this study is that the challenge I encountered in this discussion is both the core of the study but also raises problems with this practice. Focusing on the core of the study is another of my questions; how well do students' accounts of phenomena reflect or relate to a scientific account? Understanding this basic question was the basis for my involvement in the discussion. As the teacher, I posed an evaluative question. Lemke (1990) has described how the expectations of teacher and student alike is that the teacher knows the answer. This leads to a problem because the benefit of discussion is the dialogic act of sense-making. If the assumed relationship of teacher as knower and student as absorber is maintained, this inhibits development of understanding by students. Furthermore, I assert that there is more going on in a single discussion than construction of accounts. My question posed a logical, simplistic, and problematic interpretation of the on-going events in that discussion. So, while this question may be a vital assessment of student understanding; it may inhibit students' engagement with explaining phenomena in order to 'guess' the answer the teacher wants.

Discussions in science can provide opportunities to 'step outside' of traditional school roles. Discussions can be contexts for students to describe their experiences, interpret patterns in those experiences, and develop explanations for the patterns that they infer. Ultimately this is scientific. The

problem is that we are just beginning to understand whose science we are talking about. This thinking led to another question: what is the nature of the accounts that students jointly construct and collectively validate in whole group sense-making discussions?

Summarizing the problem

Discussions in science classrooms are not just talk. These discussions communicate content while also being contexts to learn sense-making practices of science that explore and explain phenomena in the world. In this way, learning science is a mutually constituent activity, meaning that knowledge and action are situated in contexts in which individuals participate (Lave & Wenger, 1991; Rogoff, 1995). Therefore, students learn scientific explanations *and* ways of making scientific explanations, through participation in contexts in which they use language to communicate with one another about ideas. For young students this presents a challenge because they are learning language, science content, particular ways of talking about ideas that are needed in science, and sense-making practices of science.

Resolving this complex challenge is not a simple task. In fact it is an impossible task given the scope of this work and the data collected. This study has a different aim, to describe the knowing and acting of students in the context of discussions that aim at joint construction and collective validation of accounts of phenomena in the world. Thus I will present in the following chapters descriptions of students' accounts of phenomena. In particular I focus on the accounts from the data set in which there is substantial student participation and

collaboration, as shown in their engagement strategies (Cazden, 1988). I will show that students, through participation, collectively establish contexts that allow them to talk about phenomena using fundamentally scientific logic. I will show that even when not present, in their contexts students discuss phenomena and invent ways to include experiences that are relevant and important. However, the experiences presented and the explanations students make may not immediately sound scientific. Ultimately the resolution to the multiple challenges is to keep the problem situated in its mutually constituent reality and to keep questions about science literacy as complex ones.

It is impossible in a study of this nature to make general statements about discussions in classrooms. It is also difficult based on the findings presented here to make inferences about the specific things that resulted in particular outcomes described here. However, I will argue that there may be value in considering different perspectives when thinking about talk in science classrooms. Further I argue that future research should consider the ways that teaching science should involve actions in the contexts that students construct in whole group sense-making discussions. Some thoughts about teaching actions to explore will be presented, looking toward future studies of discourse in science learning.

The following chapters consider multiple aspects of the questions, challenges, and issues raised here. Fundamentally it will be about the questions that arose early in this chapter. Chapter Two explores literature related to the research questions of this study. The chapter first develops a theoretical model

that is used throughout the remainder of the study and empirical findings from past studies that pursued similar questions. Chapter Three describes data collected and methods of analysis used in this study to answer the research questions. This is followed by Chapter Four which presents findings from the data, organized around the patterns that I found. Finally, Chapter Five discusses explanations and implications of the findings of this study.

Chapter 2

THEORETICAL AND EMPIRICAL CONSIDERATIONS OF JOINT CONSTRUCTION IN ELEMENTARY SCIENCE DISCUSSIONS

Introduction

This study considers how a group of students jointly construct accounts of phenomena in whole group sense-making discussions in a lower elementary classroom. Therefore this chapter will consider theoretical and empirical descriptions in the literature to examine whole class discussions. In this case, I will describe theoretical explanations and empirical findings concerning students' collaboration on the construction knowledge claims that are part of an account of phenomena. Similar descriptions can be made of the ways that claims are combined to form a collective account. Finally theoretical principles and empirical findings provide insight on the accounts that students jointly construct relate to scientific ideas about phenomena in the world.

Theoretical Model

I begin by describing a theoretical model that guided analysis in this study. Then I will present relevant empirical literature that considered similar problems in classroom contexts. The theoretical model was built through grounded theory (Glaser & Strauss, 1967) and thus evolved throughout the study. However to explain it here, I will focus on the connections between the theoretical model and my research questions. Recall that these questions were:

1. How can students' participation in joint construction of accounts be described in terms of claims and accounts?
2. How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?
3. What is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

Before considering these questions in detail, it is important to clarify what is important in these questions that will be the focus of data analysis. Since I was interested participation in whole class sense-making discussions one might ask how to examine students' participation. Whole class sense-making discussions are "situated in historical development of on-going activity (pg. 51, Lave & Wenger, 1991)." Therefore students' actions in discussions must be considered as situated in on-going activity. Students' actions, primarily focused on their talk, can show both the ways that students collaborate with one another and the practices they engage in to negotiate meaning. Therefore an assumption is that students, through their participation, negotiate situated meanings of phenomena and explanations (Lave & Wenger, 1991). Negotiation of meanings leads to acquisition of practices and understandings of science. Therefore, for the purposes of this study, I am interested in the ways that students engage in oral discussions with one another. Within discussions each individual, through their contributions (or lack of contribution) helps to define

through dialogic interaction meanings and individuals in relation to one another (Bakhtin, 1986).

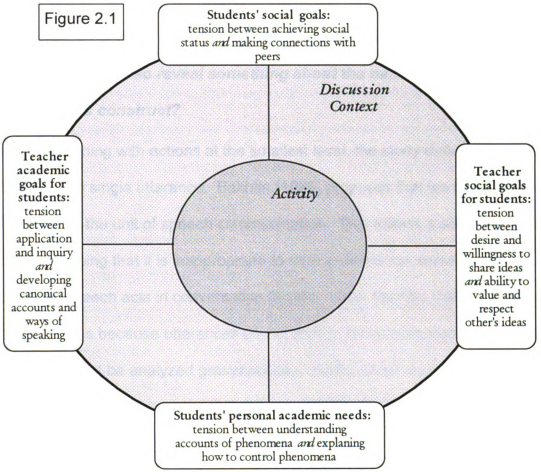
Participation: How can students' participation in jointly constructed accounts be described in terms of claims and accounts?

The challenge is determining how to examine situated activity and practice. One perspective would be to think about the nature of participant frameworks, which considers the ways that participants align themselves with others and the ways they position themselves with respect to the content of a discussion (O'Conner & Micheals, 1996). Examination of participant frameworks includes the on-going historical activity with a focus on students' actions. However, this will not be sufficient because this study is also interested in the meanings that are constructed through dialogic interactions. Furthermore, this does not allow sufficient distinction between social and academic goals in discussions. Therefore, the model used in this study (represented in Figure 2.1 below) describes discussion contexts in which there is on-going activity.

One way think about students' participation in discussion contexts is to consider how different alignments with fellow participants and positioning with respect to content allow activities that accomplish goals and purposes in the discussion. I will simplify this here to two continua (shown in Figure 2.1) that intersect orthogonally at the level of the activity with one focused on the students and the other focused on the teacher. The student continuum considers students' concerns with status and connection at one end and their academic needs on the other. Similarly the teacher continuum has goals for students'

participation and communication and goals for their academic learning at the other. Given the actions of participants in the situation, the activity in the discussion context, can shift in any direction along either continuum. For example, the traditional teacher triadic dialogue (Lemke, 1990) would lay on the teacher continuum very near the academic learning end and far away from students' status and connection goals. On the other hand, students telling about a weekend trip or their Christmas gifts will probably move toward the student status and connection end and far away from academic learning.

Figure 2.1



Unfortunately, this theoretical model is not complete. There are two problems related to the model that need to be resolved in order to clarify this. First, there is the problem comes in describing the actions that take place within the activity. Then, since the study considers joint construction it will be important to describe how things become taken as shared (Cobb & Bowers, 1999; Cobb & Yackel, 1995) in a activity and the discussion context. Some of the solution to these problems comes from considering issues of language that students used in the discussions.

Language: How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?

Beginning with actions at the smallest level, the study defined the unit of analysis as a single utterance. Bakhtin (1986) proposes that we consider the utterance as the unit of speech communication. This follows a sociolinguistic tradition arguing that it is inappropriate to treat grammatical sentence units when analyzing speech acts in conversation.(Austin, 1999; Bakhtin, 1986; Coulthard, 1985). This is because utterances do not always follow grammatical forms and thus should not be analyzed grammatically. Furthermore, each utterance becomes a part of the context that defines individuals and ideas in relation to one another. As a result, this dialogism between individuals and ideas leads to each utterance having multiple meanings in any given context. (Bakhtin, 1986)

Therefore it becomes important to think about both the nature of the utterance and its polysemous meaning in order to consider each utterance in each particular context.

In order to analyze the nature and meaning of utterances rests on further theoretical positions. I have thought of this in terms of speech acts. Linguists' descriptions of speech acts rest on philosophical, theoretical and empirical work (Jaworski & Coupland, 1999). Relevant to this study is the notion of speech acts in discussions. Theorists have described speech acts in terms of the form and function of utterances in a discussion (Austin, 1999; Grice, 1999). Specifically I think about forms as the nature of the utterance and function as the possible meanings an utterance can carry. Sinclair (cited in Coulthard, 1985) proposed 22 speech acts that fall into three categories; meta-interactive, interactive, and turn-taking. This study will follow this, focusing on the interactive utterances, to look at their semantic meanings. Meta-interactive utterances can be thought of as talk about the talk. Turn-taking utterances help manage speakers and turns in discussions. These are not as prominent in this discussion.

In terms of science education, theories about language used in interaction with others come together in Lemke's (1990) comprehensive analysis of oral language in high school science classrooms. His over-riding construct of semantic relationships and thematic patterns serves was a foundational theoretical and analytic framework in this study. A semantic relationship involves considering how meanings of words fit together to communicate particular ideas. This relates to utterances that should have discernable semantic relationships.

Thematic patterns are patterns of semantic relationships that describe particular content. (Lemke, 1990) Therefore to consider thematic patterns in discussions requires looking at relationships between utterances. Therefore thematic patterns characterize the nature of collective knowledge claims in a discussion. Discussions in elementary classrooms will not reveal the complexity of thematic patterns that Lemke found. However, this is a useful approach to analyzing students' sense-making in science.

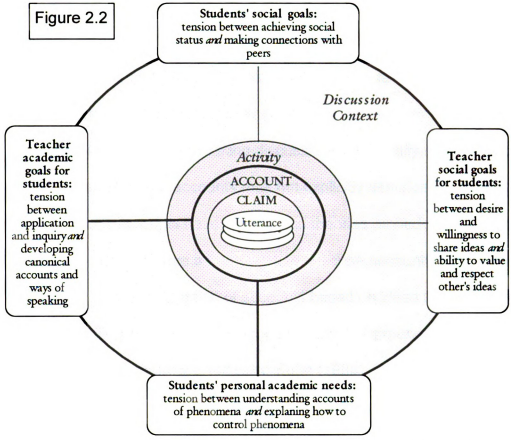
Thematic patterns are important in resolving the second problem with the theoretical model. Within activity in a discussion context, in order to have joint construction, utterances must be connected or related to one another. This focuses on how utterances can become taken as shared (Cobb & Bowers, 1999; Cobb & Yackel, 1995) in activity and discussion contexts. Thematic patterns are similar to floors recognizing that speakers and listeners share "psychological time and space (Edelsky, 1993)." In other words, speakers and listeners attempt to share a topic and a discussion space and time. This follows conversational maxims that contributions reflect some cooperative purposes and a generally accepted direction of discussion (Grice, 1999). Thus the assumption is that each student utterance logically fits in the on-going activity. Therefore, I describe, for the purposes of this study, *shared utterances* as utterances that use, repeat, or revise prior utterances in the on-going activity.

This study framed science learning and knowing as activity that involves developing connected sets of claims (both empirical and theoretical) about the world, which I refer to as *accounts*. Accounts develop based on claims of

experiences and observations of phenomena, through reasoning about interpretations of patterns in observations and experiences, and hopefully result in explanations of those patterns (Anderson, 2001). This chapter considers the forms and functions of language that students use in oral discussions to construct and validate through collective processes accounts of phenomena, using oral discussions to refer to whole class sense-making discussions in elementary science teaching and learning.

This study faced a particular analytic problem regarding units of analysis and operational definitions. I identified three analyzable units to consider. The *utterance* in this study refers to a single oral language meaning unit. Utterances can, individually or combined with other utterances, form *claims.* As stated above, *claims* are single meaning units that describe or explain phenomena in the world. Claims can also stand individually or combine with other claims to form *accounts. Accounts* attempt to make general statements about the world.

Adding this to the previous model, a more complex, but also more satisfying model is revealed. This shown in Figure 2.2 revisits the former notion of continua present in the discussion. However, it is important to note that social goals in this model connect to activity, while intellectual goals connect to accounts. This study focuses on academic goals and as a result, will center observations in the data, patterns and explanations on the accounts.



Content: what is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

Finally, it is important to recall that a goal of science involves constructing, concise and reliable explanations of phenomena in the world. Scientific explanations can be referred to as models and theories and are drawn from experiences that include careful observation, data collection, and inquiry into phenomena. (Rutherford & Ahlgren, 1989) Therefore, science literacy in oral discussions implies talking in ways that develop and use scientific models and theories to explain observed and/or experienced phenomena. This study was

also concerned with the understandings that students develop of scientific models and theories. Therefore, I considered understanding as "the ability to think and act flexibly with what one knows (pg. 39, Perkins, 1998)." Therefore we can consider the how students think and act in their talk with models and theories as indicators of understanding of science.

Whole group sense-making discussions organically develop accounts of phenomena. Thus the accounts may not explicitly describe theories or models, however, such accounts have models and theories embedded in them. Therefore it helps to have a framework to describe accounts of phenomena. This study relies on the description of accounts based on ideas from Anderson (2001), that a scientific account is an interconnected set of experiences, patterns and explanations. Furthermore, following Kuhn (1993), to be scientific, an account must respond to all the evidence from the set of available experiences. Therefore a scientific account consists of an interconnected set of experiences, patterns and explanations that respond to one another. This leads to three criteria with which to evaluate a scientific account. First, the set of experiences, patterns, and explanations needs to be coherently connected with one another (hereafter referred to as coherence). Second, the range of experiences must lead to an appropriate set of patterns to explain a complete account (hereafter referred to as completeness). Finally, the resulting account can be evaluated in terms of its correspondence with a scientific account (hereafter referred to as correspondence).

Experiences have taken a special place in science curriculum, science learning, and theories of science teaching and learning. Hands-on experience is a catchword connected with science learning. The common interpretation is that this means students will learn science if they manipulate materials and experience different phenomena. There is growing understanding that experiences in school alone are not sufficient to develop scientific accounts. One problem that has been identified is that students come to school with experiences that may or may not be useful in the process of developing scientific accounts. Therefore in order to learn science students need to learn conceptualizations that reflect the ideas of science (Posner et al., 1982; Smith, 1990; Watson & Konicek, 1990). Furthermore it is important to keep in mind that in many cases students' explanations for how or why phenomena happen in the world are sensible or fit their particular sociocultural context (Kawagley, Norris-Tull, & Norris-Tull, 1998; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

Thinking about experiences and the explanations of those experiences it is possible to deconstruct the corpus of explanations suggesting that any attempt to explain reality will fail due to faults of logic in empiricism (Darrelson, 1985; Quine, 1953). However, Bazerman (1988) and Latour & Woolgar (1986) provide more productive approaches suggesting that scientific explanations come through a combination of social and empirical activity. Explanations are most productive when based on experience and situated in contexts that allow collaborative, social action to construct useful and plausible explanations. Therefore, while students' explanations may not equate the scientific explanation,

the process of explaining experiences in a social context is ultimately scientific. Furthermore, students' activity in discussions situates them in participant frameworks in which they can position themselves with respect to content.

Finally an implicit idea in this study was the importance and value of collaboration in learning. This draws from the ideas about reciprocal teaching (Collins, Brown, & Newman, 1989) and Vygotskian (1986) theories of learning. To begin with working with peers to develop explanations situates students as learners and sources of knowledge. This follows ideas of reciprocal teaching allowing students to have shared responsibility in learning and in this case developing accounts of phenomena. Furthermore the students engaged in dialogue activate the thought and language connection that is important to Vygotsky. Students' collaborating in discussions allows entry at all levels of a continuum of knowledge and invites peers to state for peers the ideas that are important in an experience.

Empirical Research

A number of research studies have considered discussions in science learning, but none have considered issues similar to the structure of this study. This structure includes consideration of early elementary students, participation and joint construction in whole group discussions, and sense-making of young learners. In the following summary of empirical research, I focus on those studies that have considered similar issues to the particular attributes that distinguish this study. Recent studies in science education have shown increased attention to the role of discourse in science learning (Hilton-Brown & Kelly, 2001). A few of

these studies look at discourse in terms of oral language used in large group sense-making discussions. Research has also considered how students develop explanations in whole group discussions. Findings from this research have focused on some central themes, including structure of discourse, students' interactions with one another, and the ways that discussions become challenging places to make sense of ideas. The findings from these studies help flesh out the terrain that will be important in this study.

Individuals as participants in a group

Several studies consider the ways participants' identities and social positions affect both the degree to which they are willing to participate and the value that peers place on the contribution of that individual. Thinking about students' social position and participation in talks presents a challenge that teachers often think about in planning and teaching in group activity. Gallas's (1995) description of "big talkers" dominating discussions and intimidating peers offers evidence (and later suggestions for resolution) of the problems that we all intuitively know are part of whole-group sense making discussions. This becomes a more complex problem if the issues of domination and intimidation are not as apparent as the description Gallas (1995) provides of two boys dominating discussions.

Smith and Anderson (1999) describe a small group of pre-service teachers working in a social context to learn science. They show that learners' personal identities as being knowledgeable of science impact their interactions with subject matter and their peers when learning in socio-cultural contexts.

While there are many differences between adult learners and students in their early experiences in school, the point is that students' personal efficacy as knowing science, impacted the actions that they took in classrooms. However, personal images as being knowledgeable learners of science are not just issues for pre-service teachers. Barton (1998) shows that students' identities and personal efficacy impacted their approaches to science learning and their interactions with peers in both traditional and non-traditional science learning contexts. Thus this research suggests that an individual's sense of personal efficacy as a science learner is important to actions that individual takes in science learning.

This complexity of personal efficacy in science learning is confounded by the ways that teachers and curriculum constrain and bound science learning to particular ways of knowing. It seems clear that students' linguistic abilities and cultural ways of knowing impact personal and public perceptions of their abilities to think and act scientifically. Some researchers argue that everyday sense-making offers valid explanations of phenomena, but more importantly offers more opportunities to engage in discussions that include more participants (Warren et al., 2001). Similarly Kawagley, Norris-Tull, and Norris-Tull (1998) show that students' worldviews, in their case Native American students, impact students' ways of knowing which has consequences for their science learning. The point of these studies is that students have different ways of perceiving the world that are not necessarily wrong, but do not fit the canon of science. This connects to this study because teachers and students bring implicit images of science to

classrooms, which impact their impressions of students' actions. If those actions, as the above cited research showed, do not share images of science, there is potential to marginalize different ways of knowing and acting in science.

One finding from research regarding students' participation in whole-group discussions in science classrooms is that students are concerned with status and friendship groups in the classroom. These concerns and issues do not directly relate to learning science and lead to constraints in learning for one set of high school students. (Kelly & Chen, 1999) Further research suggests that in when learning is situated in whole-group contexts it is important to consider the social contexts of students' intellectual activity in science learning. Crawford, Kelly, and Brown (2000) describe a teacher that attempted to lead more discussions in classrooms, situate learning in social activity, and to share control of these things with students. The research shows how this arrangement led to learning through social processes that focused on intellectual accomplishments of high school students. The focus of this study is on intellectual activity in social contexts. Implicit in these findings is that there are personal efficacy and individual social goals that play out in classroom contexts. However, more work needs to be done to elaborate on the specifics of individual goals and purposes in classroom contexts. One question to ask is how students' social purposes, their need for status, affiliation, and connection, play out in different contexts.

Other research looks more specifically at the ways that status, affiliation, and connection impact participation and learning in socially rich science learning environments. Kurth, Anderson, and Palincsar (2002) consider the social

aspects of students' purposes in interactions in small group science investigations. They describe how students' perceived status of group members impacted the ways that members interact with one another. As a result students of low status experienced marginalization of participation (Kurth et al., 2002). Bianchini (1997) describes an intervention in perceptions of social status in small group work by introducing a model of participant roles to mitigate issues of status. However, she explains that simply structuring roles in groups is not enough to tackle complex issues related to social goals and purposes in small groups. Further, Bianchini (1997) argues that "problems of [students] status are deeply enmeshed in classroom fabric (pg. 1060)." Thus even in small groups, there are problems of status, affiliation, and connection between students.

Semantics of oral language and joint construction

Lemke (1990) describes fundamental research on oral language use in science classrooms. His thorough study of talk in science shows how learning science means learning to talk science. According to Lemke (1990), many high school science classrooms rely on triadic dialogues to communicate science knowledge to students. Triadic dialogues involve a teacher question, the student responds and the teacher then evaluates the response. However, he also found that there were patterned forms of communication in science classrooms. His analysis considers the semantic relationships and thematic patterns of language occurring in science talk in school. A semantic relationship describes relationships between words in utterances and a thematic pattern relates semantic relationships. (Lemke, 1990) This description of talk in science

classrooms revolutionized thinking about the language of science in school. However, all the claims in this study came from secondary science learning and a natural question is whether the same patterns hold up across grade levels.

A number of different studies look at the nature of oral discussions in science learning, describing what might be thought of as the "anatomy" (c.f. Gallas, 1995) of a discussion in science learning. While Gallas (1995) does not go into the linguistic detail that Lemke (1990) provides, she looks at the ways that students talk in whole group discussions. Based on her research, she develops a theory that students through their discussions use oral language in a cyclic process to propose, support, and extend theories about phenomena in the world. (Gallas, 1995) Considering students interacting in a large group, as Gallas (1995) does is helpful to thinking about the nature of language and interactions that take place in classrooms.

Similarly joint construction in oral discussions has also been researched. Barnes & Todd (1995) also describe the nature of collaboration in discussions. They describe students initiating, extending, eliciting and responding to assertions in discussions, arguing that these discourse moves follow a pattern in discussions that allow students to collaborate on sense-making. A central difference for Barnes & Todd (1995) is that their framework does not assume culmination of the accounts that students are constructing.

Gallas (1995) indicates that students rarely evaluate claims and work hard to maintain claims that are already in the discussion. Barnes and Todd (1995) take an even stronger stance saying that students do not evaluate claims.

However, the consequence of a focusing on the group is that we do not get much information about the individual utterances that make up the discussion. Furthermore, while Barnes and Todd (1995) include empirical knowledge claims, the discussions Gallas (1995) describes focus on theory and do not help consider empirical knowledge in classroom discussions.

Research also looks at interactions in classroom discussions. This work considers the social and cultural aspects of learning to participate in science discussions that promote learning, focusing on small group work (Anderson, Holland, & Palincsar, 1997; Hogan, Nastasi, & Pressley, 2000) or whole class interactions (Kelly & Chen, 1999; Reddy, Jacobs, McCrohon, & Herrenkohl, 1998; Smith & Anderson, 1999; Warren et al., 2001). Hogan, Nastasi, & Pressley (2000) examine the utterances of students in small group activities in high school settings. Their analysis codes the nature of students' statements which leads to describing the reasoning pattern that students used in their small group activity. (Hogan et al., 2000) Warren, Ballenger, Ogonowski, Rosebery, and Hudicourt-Barnes (2001) consider whole class discussions and the ways that students use everyday language and embodied imagining, a strategy of thinking of what it might be like to be a part of some phenomenon, to construct knowledge of the world. This study seeks to extend on these bodies of work, adding more information about the semantic relationships that young students construct in whole group discussions.

Sense-making in discussions

Another approach to considering discussions in science classrooms looks at the reasoning students engage in during discussions. This requires looking closely at interactions between students collaborating in discussions. Hogan, Nastasi, and Pressley (2000) describe the interaction spaces that students and teachers engage in when collaborating on scientific reasoning. They found significantly different interaction spaces when students worked alone in groups as compared to with the teacher in a whole group. A difference that they found was that reasoning in small groups was more exploratory, while discussions including the teacher had higher levels of reasoning due to teacher actions in the discussion. (Hogan et al., 2000) What is not clear from this study is what the outcome of higher levels of reasoning was on students' understanding.

There have been attempts to consider how the nature of discussions and the reasoning of students might lead to developing understanding of scientific ideas. Bloom (2001) considers whole group sense-making discussions to examine the ways that students' claims in discussions lead to particular accounts[5] of phenomena. Bloom shows that students, in the context of an on-going discussion, can end up making divergent claims that do not lead to reasoning and as a result create chaotic systems of explanations for students to interpret. As a result students may struggle to understand science based on sense-making discussions. This is an important caveat to consider in

[5] Account follows the term that I have used throughout this study. Bloom does not refer to accounts. In fact he might argue that this is not an appropriate term since his work showed chaotic outcomes rather than convergent ones. I present it here as one way to think about students' understanding in discussions.

discussions and thus why this study centers on the students' accounts and the understandings these accounts lead to. The data selection process led to the selection of convergent accounts (since I used student uptake to guide selection[6]) so the chaotic problem Bloom (2001) identified, while important to consider, is not relevant here.

Several studies closely examine the ways that students make sense of phenomena in science learning. Hulland and Munby (1994) consider sense-making of students in small and large group discussions. They compare the sense-making of two students in discussions. They found that one student used what they describe as scientific reasoning, while the other relied more on stories and metaphors. (Hulland & Munby, 1994) The findings from this research are important to this study, but they only reveal how individual students make sense of phenomena.

Schauble, Klopfer, and Raghavan (1991) also describe the kinds of sense-making used by groups of students during hands-on science experiments. They found that groups primarily used an engineering model to conduct investigations and make sense of the results of their investigations. This is more of an application of science knowledge to solve a problem, or as they describe, "a practical exploration for purposes of achieving a desired effect (pg 860)." (Scauble et al., 1991) These findings do look at groups of students, but the context of that study was significantly different than this study. The differences of note were that Schauble et.al. (1991) investigate reasoning of students in

[6] Chapter Three describes methodologies used in this study. A more complete explanation of the data selection process is found in that chapter.

intermediate grades (5th and 6th). This study looks at much younger students. Furthermore, Schauble et.al. (1991) describe results of students in different contexts in which students received different tasks to investigate the reasoning students used based on task structures. This study follows a naturalistic approach in which there are no interventions in the tasks students were given.

Rath and Brown (1996) also describe students' reasoning about phenomena. They identify six modes of engagement that students used to make sense of phenomena during investigations in a summer camp setting. Similar to other research, they consider students' reasoning in small group settings. Furthermore, the intensive focus on science for a period of three weeks in a summer camp setting and the fact that the research includes students from a range of ages in the elementary span distinguishes this research. Based on findings from their research, Rath and Brown (1996) argue that it is important to consider both the students social and conceptual orientations in sense-making. (Rath & Brown, 1996) This study relies on these findings but makes the distinction of focusing on one classroom of lower elementary students over two years. In addition, Rath and Brown (1996) focus on small groups while this study considers whole class discussions.

Summary

There are several points to revisit in this chapter. We can see the ways that students in whole group sense-making discussions participate and share utterances of peers to construct accounts of phenomena. Furthermore, the remainder of this dissertation will use the theoretical model described here to

frame the argument of the dissertation. This argument is summarized as saying that students engaged in joint construction of accounts rely on certain modes of engagement that they find meaningful and useful. These modes of engagement are taken as shared, though there are never explicit statements made by students in terms of what the students find meaningful and useful. These modes of engagement do not ultimately sound scientific. However, on closer examination we can see how students are engaged in scientific practices based on the set of available experiences they have available. Subsequent chapters describe the methods and data used in this study, patterns in that data, and explanations of those patterns.

Chapter 3

Methods for researching joint construction accounts

Introduction

This chapter summarizes the participants, context, data and methods used in this study. I was curious about how discussion helped students learn science and develop proficiencies in scientific discourses. The research asked how one group of first to third grade students used language in whole group discussions to jointly construct explanations of phenomena in the world.

It is important to note that the study and the data collected include me as a teacher in the context. There were a couple of reasons to design the study this way. To begin with I wanted to study the effects of particular strategies of instruction. To control those aspects of instruction as much as possible, I chose to establish myself as the teacher. In addition, this structure situated my as a participant in the context allowing the benefits of teacher research (Cochran-Smith & Lytle, 1999). This helped me understand the classroom context and social positions of students in the classroom. In addition it allowed me to think about how students participated in a social context, and as a result, learned about subject matter through participation in whole group discussions. This helped me understand better how students talk to one another and collaborate on developing understandings of phenomena in the world.

Of course there are drawbacks to this model of research. As a participant in the data that were collected, I naturally influenced the outcomes in that

context. Furthermore, my knowledge of the subject matter and theoretical ideas about teaching and learning were quite different than that of a typical classroom teacher. This potentially impacted the outcomes as well. Finally, my presence as a volunteer teacher in the classroom allowed me to assume a position of relatively low accountability. As a result I did not feel the pressures of the highly structured science curriculum of the district. However, I chose to accept these drawbacks because my main aim throughout the study was to arrive at "thick descriptions" (Geertz, 1973) of classroom phenomena. This suggested that I needed to do more than observe; I also needed to participate.

This chapter begins with a summary of the data collected, including, the participants, context, and setting. The chapter concludes with despcriptions of the particular analytic methods related to findings reported in Chapter 4.

Context, Social Setting, and Participants

The study took place in one classroom, a multiage setting spanning three academic years. I taught science, and conducted the study, in the classroom beginning in September of 2000 and ending in June 2002. Students remained in the classroom for up to three years. Therefore some students were only in Year One or Year Two of the study. However a small subset of students was in both years of the study. While there might be differences in the length of experience that students had in the context, this was not the question of the study. I was not seeking to look at individual performance in the context; rather the intent was to provide an interpretive account of things happening in the classroom [ref Erickson, 1986]. The following descriptions contain details not often included in

descriptions of participants, but I feel that they give a better glimpse into the participants and ultimately, this classroom context.

The school was situated in a neighborhood in an urban district (Weiner, 2000). The classroom was an open concept classroom shared by four teachers leading separate classes. Three of the teachers of these classrooms led multi-aged classes and collaborated on many activities and teaching plans. The classroom surprised most visitors. It was well equipped in contrast with common assumptions about urban schools. It was relatively quiet, given the open concept. Finally, there was a great deal of student autonomy. This was necessary to facilitate the multi-age program. There was whole group teaching, but primarily instruction was tailored to each student. In all content areas there was limited use of textbook based curriculum materials. Students wrote in journals in all subject areas. Talk about ideas was a regular activity of this classroom; as a result students had multiple experiences talking with one another about their ideas.

During Year One there were almost equal numbers of boys (nine) and girls (eight) in the class. There were seven children in first grade, four in second grade, and six in third grade. Racially the class was predominantly (eleven of the seventeen students) African American. There were two European American students, one Asian American student, one Hispanic student, and two Bi-Racial students. There was a twin boy and girl in the second grade. Two students received services for diagnosed learning disabilities; others waited on assessment. Based on anecdotal information from students, teacher reports,

and other information, a few things were known about students' home lives. One student lived in temporary housing (motels). Three of the seventeen children lived with both biological parents in their home. Three of the children reported that one of their parents was incarcerated. One first-grade boy was in a single parent home due to the death of his father. Finally, two students lived in adoptive or foster care homes.

Between Year One and Year Two, district boundaries were re-drawn, resulting in school population shifts. Only one student from year one left the school. Six of the eighteen children were new to the school, eight Year One students remained, and four students moved up from kindergarten within the school. In Year Two there were more girls (eleven) than boys (seven). There were grade-level shifts leading to disproportionate age groupings. There were four first grade students, seven second grade students, and eight third grade students. Again the predominant (twelve of eighteen students) racial group was African American. The remaining groups included four European American students and two Bi-Racial students. By parent choice, the second grade twins from Year One were separated, leaving the girl in the classroom and placing the boy in another classroom in the building. During Year Two, four students received services for diagnosed learning disabilities. Only one student had a parent incarcerated, another was under felony warrant. Three students lived with both biological parents. The student from Year One whose father died remained in the classroom during Year Two.

As the science teacher, I came to the school with a rather non-traditional set of experiences for a primary grades teacher. I came from upper-middle class home where both of my biological, European American parents lived. My undergraduate education was in science. My teacher education came during a Master Degree Program in science and education and completing requirements for secondary teacher certification in Oklahoma. However, I spent one year teaching elementary science in third and fourth grades prior to this teaching experience. Before pursuit of a Doctorate I taught science lessons to various groups in an informal setting.

The classroom teacher was former graduate student of education with more than eight years teaching experience. Four years were at this school, prior to that she taught in another district school as a classroom teacher and a Reading Recovery teacher. She had a strong commitment to teacher education; often allowing teacher education students to observe the classroom. She worked closely with two other teachers, who had similar multi-age classrooms.

Data Sources

As a participant observer {Atkinson, 1994 #61}, I collected a range of data. Two primary data sources serve this work: videotapes and field notes. Field notes were written while watching the regular classroom teacher, or immediately after I taught a science lesson. Whole group and some small groups were recorded using a digital video camera and cordless microphone. These were transferred to a computer, digitized, in some cases transcribed and analyzed.

While the computer encoded the video into MPEG format[7] I wrote viewing notes, which served as a second set of field notes. The viewing notes catalogued events including an extended narrative responding to specific questions about observations in the video. This primary data set, videotapes and field notes, was complimented with copies of student journals, individual work on handouts and worksheets, chart paper of whole group writings, group composed class books, and informal and formal interviews.

Since I wanted to think about the times that students collaborated in discussions I first reviewed all sixty-six videotapes. In this review I looked for moments of potential *shared utterances*. Potential was determined by any time that a student repeated the idea of another student or themselves in the discussion. This review generated a catalogue of instances, which documented the date, time, discussion, speaker, and a description of the events in that discussion or moment. This criterion and selection procedure identified five hundred forty instances that deserved further investigation. It is important to note that this does not mean students stated five hundred forty original ideas, but rather that was the number of times that I could clearly identify when one student used another student's idea or thought or gave another student credit for an idea.

From this catalogue of potential shared utterances I looked for patterns to suggest that students were developing *thematic sequences*. This was a first attempt to identify moments when students seemed to collaborate with one another. In order to identify these moments I referred to the video summaries, transcripts, and occasionally the original video tape. Looking at the catalogue of

[7] This is a rather lengthy process taking 60-90 minutes.

shared utterances and patterns, I identified thirty-one selections (which all included multiple shared utterances) when students were doing more than merely repeating previous statements.

To reduce the thirty-one selections to a manageable number, I revisited these particular selections. I looked again at transcripts, video tape summaries, and video tapes as needed to make further distinctions in these selections. I attempted to describe the language, content, and phenomena involved in the selection. Compiling these descriptions of selections, I noticed that more than one third (eleven of thirty-one) of these selections involved reconciling various combinations of students' experiences with explanations of phenomena. This subset of eleven discussions was further reduced to six discussions including two discussions in physical, earth and life sciences to create a manageable data set that represented a range of subject matter.

Analysis followed approaches designed to be consistent with the research questions. Students' turns in transcripts were broken into discernable utterances. These relied on pauses, topic shifts, and place holding expressions (umm, err, etc.) to identify bounds of an utterance. Transcriptions were formatted to include short pauses (/) and long pauses (//), rising intonation (^), and overlapping speech (underlined). Commentary about gestures and interactive issues, such as jumping in, were included in *italics*. Before describing specific methods, it will help to have an understanding of the six discussion selections. For analytic purposes (the discussion contained too many topics to maintain clear analysis), one discussion selection was broken into two parts, making

seven selections. Appendix A presents the seven selected and analyzed discussions in narrative formats followed by complete transcripts.

In the context of this dissertation it will be difficult to consider all these discussion selections in detail. Since I was intimately involved in the context, the students were familiar to me and the topics were ones that I planned lessons around, it is easier for me to navigate all the discussions, keeping them in my mind. However, to make this more comprehensible to the reader, I would like to focus on a subset of focal discussion for this dissertation. In particular I am interested in discussions that included the greatest number of students involved and the highest percentages of shared utterances. Since a central focus of this study was collaboration in discussions, it makes sense to focus on ones that had high levels of student involvement. To determine this, I counted the number of students participating in the discussion, the number of utterances each speaker made and the number of times each speaker's utterances were shared by another member of the group. In short I wanted discussions that had the greatest number of students participating and the highest percentage of students' utterances being shared. This led to the selection of two focal discussions. From this set, the third and sixth discussions are treated as focal discussions which provide the majority of the sample analysis reported and described here.

Data Analysis

Preceding sections of this chapter imply relevant methods for analysis. This section attempts to make explicit the specific analytic tools and procedures used in each portion of the analysis (these are summarized as coding schemes

in Appendix B). These descriptions of analysis procedures are organized according to the research questions. The following descriptions of methods will explain how the data were analyzed and the procedures that led to interpretation of patterns that are reported in Chapter 4. Specifically, this will describe how I analyzed the semantic relationships of utterances and shared utterances, the analysis of thematic patterns in the construction of accounts, and how I analyzed the nature of the accounts that students jointly constructed.

Participation: how can students' participation in joint construction of accounts be described in terms of claims and accounts?

To examine students participation I began by looking at each utterance Analysis of utterances could not rely on grammatical forms that students used in their utterances because oral language does not always match the grammatical form of written language (Austin, 1999; Bakhtin, 1986; Coulthard, 1985; Grice, 1999). In addition, this would not help develop understandings of students' use of language to develop thematic sequences that positioned themselves around ideas. Therefore, analysis turned to a semantic analysis of utterances (Lemke, 1990). Such an analysis looks at utterances in terms of how words relate to one another. Initially coding followed Lemke's description of semantic relationships common to the language of science in secondary classrooms. However, the prominent use of the pronoun you, which is not included in Lemke's descriptions, made it necessary to develop additional semantic relationships that described utterances that made claims about human agency.

Lemke (1990) suggests that semantic relationships alone will not be sufficient in analysis of oral language in science classrooms. The point is that talking, and in this case talking in science, is not about just knowing the meaning of words, it is also about how words when put together, have particular meaning. Furthermore, there are connections between the meanings these meanings that Lemke (1990) refers to as 'thematic development strategies.' Thematic development strategies describe the nature of what I have called thematic sequences. I looked at coded utterances for consistency and patterns to infer the thematic development strategies that students used in discussions. These thematic development strategies were used to describe the nature of students' claims, which consequently were part of thematic sequences. Thus this became an examination of relationships between students' utterances in the development of knowledge claims.

The thematic sequences were helpful in describing what was meaningful and useful to students in the discussion contexts. Based on this coding, it was possible to develop discussion maps that showed the main utterances in a thematic sequence, whether these utterances were shared, and which shared utterances received the most attention in the discussion context. Discussion maps are similar to concept maps, showing the overall progression of utterances, claims, and thematic sequences of discursive activity in a discussion context. The discussion maps are arranged with a vertical timeline running the start of the discussion at the top of the figure to the end of the discussion at the bottom of the figure. A box identifies each thematic sequence, with individual utterances

also running vertically inside the thematic sequence. Arrows are sure to connect shared utterances with the initial utterance within and across thematic sequences.

Discussion maps provided insight into the thematic sequences that students most engaged in talking about. These same maps provided insight into the ways that students made accounts that were complete and coherent in their own terms. The maps were helpful in identifying patterns in the shared utterances. Such patterns were useful in generating narratives of the accounts, summaries of the claims, and in identifying the things that were meaningful and useful in an account of phenomena.

Language: How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?

This study also analyzed the accounts that students jointly constructed in the course of the discussions for their accuracy and also to highlight challenges faced by teachers and students alike in such discussion contexts. This analysis starts with the analysis of students' utterances, to look at how relationships between knowledge claims combined to form accounts of phenomena. This maintained attention on the ways that students positioned ideas in the discussion context.

I also wanted to know about the kind of understanding that was possible in the particular context of the discussion. This kind of analysis could not be satisfied by looking at either utterances or thematic sequences. Rather it

required looking across the thematic sequences to the complete account. Because of this, methods of analysis took on two approaches: 1) first looking at knowledge claims to determine the nature and substance of the claim and 2) second examining how students combined claims in the account.

The first analytic approach focused on the knowledge claims students used to communicate aspects of a scientific account. This essentially applied a heuristic of scientific activity (Anderson, 2001; Anderson et al., 1997; Kurth et al., 2002) which considered whether utterances expressed experiences, patterns or explanations. The fundamental notion is that scientific accounts consist of connected sets of claims that explain patterns of phenomena in the world. Connecting this to the heuristic, experiences are either observations of events or actions that provide the user observations of events related to phenomena.

Content: What is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

Epistemologically science knowledge is based on a large set of experiences in the world. For example, a person can observe the Sun each morning in the eastern sky and every evening the Sun is in the western sky. Patterns then attempt to describe relationships between the set of experiences that students consider. So the observer can infer the pattern that the Sun rises in the east and sets in the west. Finally explanations attempt to tell why particular patterns occur. In the case of the Sun rising, one explanation is that

the Sun orbits around the Earth. Another explanation suggests that the Earth is spinning, resulting in different sides of the Earth facing the Sun.

From this scientific perspective utterances were coded as communicating experiences, patterns and explanations. Given that this is a somewhat hierarchical model, the hypothesis would be that there would be a large number of experiences, leading to a smaller number of patterns, and resulting in the fewest number of explanations (Anderson, 2001; Anderson et al., 1997; Kurth et al., 2002). Utterances were further coded, building on a constant comparative approach [ref] for the ways that they asserted, elaborated, or evaluated preceding claims of the developing account. Looking at the coded utterances it was possible to begin to develop an idea about the accounts students were constructing.

Since a central focus of this study was on the participant frameworks that students developed, a remaining question asks how the participant framework leads to the development of an account. This required a shift in units of analyses to look at the collective account generated by students. The problem is that it has been shown that students' explanations of phenomena do not always match the scientific account of phenomena (Posner et al., 1982; Smith, 1990; Watson & Konicek, 1990). Therefore it is likely that the accounts students generated might not reflect a scientific account. In order to conduct an analysis of accounts, the main claims made by students and accepted by their peers were synthesized into a single account. Then a scientific account for the same phenomena was

constructed. Finally the two accounts were compared for consistencies and inconsistencies.

Summary and looking forward

This chapter has presented the data sources and methods of analysis used in this study. In particular, the data was described in detail in order to familiarize the reader with the data and context, but also to highlight the two focal discussions. These focal discussions will be the primary pieces analyzed in the following chapter. Finally, Chapter Five discusses those findings and offers explanations about why and how they make sense.

Chapter 4

PATTERNS OF JOINT CONSTRUCTION IN ELEMENTARY SCIENCE DISCUSSIONS

Introduction

To this point I have described a theoretical model, past empirical work, the context and data collection, and methods for analysis for this study. These descriptions focused on ways to explore the research questions. Recall that the overarching research question asked for descriptions of the ways that groups of students collaborate on explanations of phenomena in the world. This involved three sub-questions:

1. How can students' participation in joint construction of accounts be described in terms of claims and accounts?
2. How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?
3. What is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

These questions will again serve as an organizing structure to describe patterns in findings related to participation, language, and content. Specific methods of analysis will not be discussed here. Chapter Three described these methods.

Appendix A includes narrative and transcribed version of each selected discussion. Appendix B defines the coding scheme and operational definitions for analysis.

The findings presented in this chapter show patterns in the students' utterances, claims, and accounts of phenomena. Presentation of these patterns first considers the focal discussions, followed by relevant patterns from the other selected discussions. Patterns in the data reveal how students' shared utterances were built around shared semantic relationships that involved statements about human agents exerting control over phenomena in the world. Students' shared utterances were related in thematic sequences that led to joint construction of accounts. Analysis of patterns in students' accounts revealed that their sense-making focused on describing patterns in their experiences that allowed students to describe ways to exert control over phenomena. Therefore, the central claim of this chapter is that the accounts that seemed meaningful and useful for students focused on joint construction of claims and accounts about human agents acting in the world. Conversely, when I attempted to alter the thematic and semantic nature of claims and accounts to be about phenomena in the world abstracted from human action in the world, the result was reduction of joint construction.

Participation: How can students' participation in joint construction of accounts be described in terms of claims and accounts?

A fundamental goal of this study was to arrive at some understanding of the ways students jointly constructed accounts in collaborative discussions.

Therefore it was initially important to identify patterns in students' participation and the nature of utterances that supported students' joint construction. This section considers students' participation by looking at patterns in students' shared utterances. Looking at the focal discussions, the following findings report students' use of shared utterances to participate and the role of human agency in students' shared utterances.

Participation relies on shared utterances

It seems obvious that participation relies on shared utterances. However the complexities of participation and the role shared utterances is important. The following section describes the ways that students shared utterances by looking at discussion maps[8] of each focal discussion. Then more general descriptions of shared utterances are made across the selected discussions.

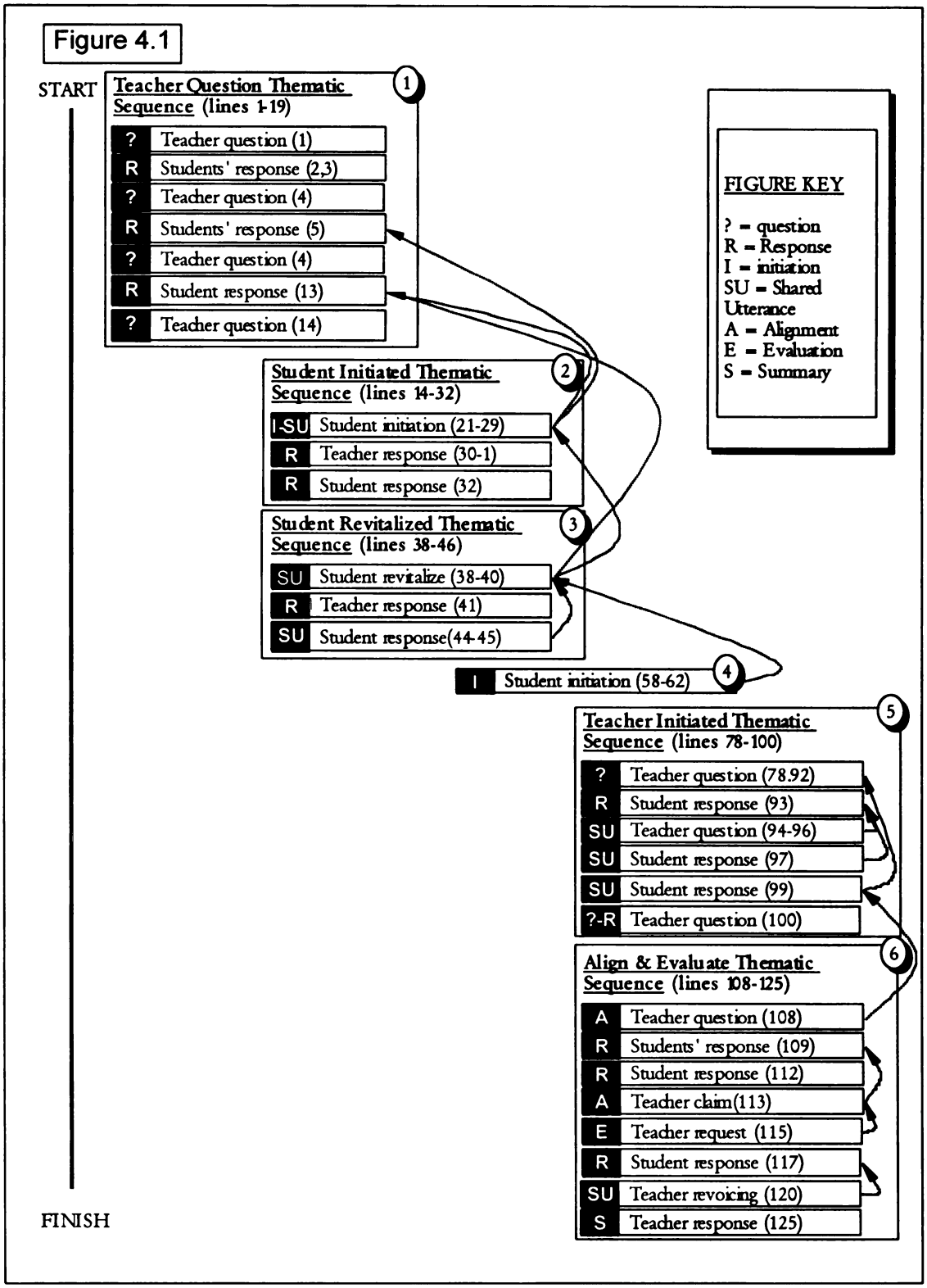
Wind and Kites

Figure 4.1 represents the wind and kites discussion. It focuses on the actions students made in the discussion. Each large box is a thematic sequence[9], with speakers represented inside these boxes. The smaller boxes represent speaker's turns. It is important to note that this analysis focuses on speaker's turns, of which each turn may include one or more shared utterances. Arrows show uses of shared utterances. Solid arrows stay with in the thematic sequence, while dashed arrows represent shared utterances across thematic sequences. The grey circles number the thematic sequences to enable further

[8] See chapter 3 and the appendix for descriptions of discussion maps.
[9] Thematic sequences receive more detailed attention later in this chapter.

discussion below. In the upper right hand corner a grey box is a key that explains abbreviations in the boxes.

Figure 4.1



The first thematic sequence (circle 1) shows what might be thought of as a triadic dialogue with teacher questions followed by student responses. Subsequent sequences in this discussion included greater student talk and more shared utterances within and across sequences. The next three thematic sequences indicated by circles two, three, and four, show students using shared utterances for various purposes. At circle two, Marquisha initiated claims about flying kites, building on a prior student claim about string (shown by the dashed line). Next, at circle three, Lora shared Marquisha's idea, shown by the dashed arrow, to revitalize the thematic sequence initiated by Marquisha. Finally, circle four presented an interesting use of shared utterances. Rodger referred to an earlier utterance, to initiate a thematic sequence about making kites. However, the group did not share his claims. This is seen in figure 4.1 since no arrows point to the box representing this claim.

After this I initiated a new thematic sequence (circle five). Previously the thematic sequences that I initiated led to triadic dialogues. However, this initiation built into a thematic sequence (circle six) that involved me aligning students and ideas, providing opportunities for students to engage with theories and one another. Ultimately my summary statement, line 125, implied there was no correct answer and that we now had a jointly constructed question.

Figure 4.1 highlights points in the discussion when students shared utterances to participate within or across thematic sequences. Looking at this discussion map it is possible to see that shared utterances did support students'

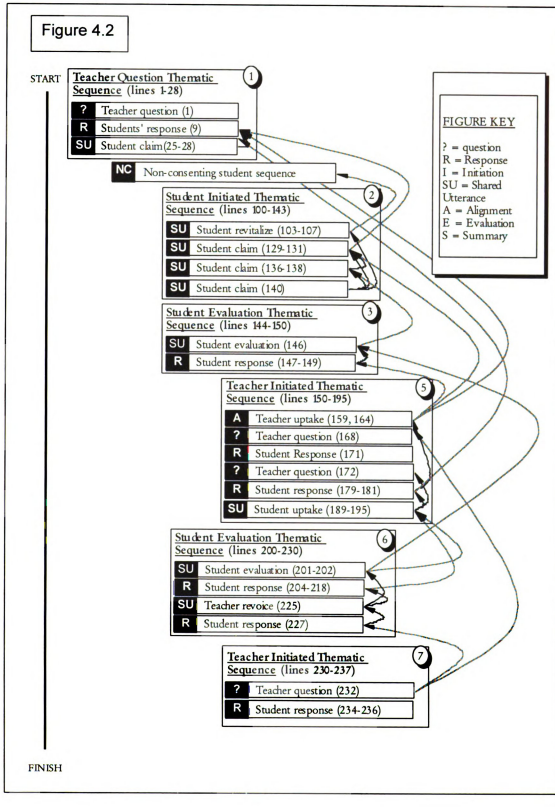
participation, but it does not show how this took place. For that sort of analysis, it will be necessary to look more closely at transcripts of the thematic sequences.

What are seeds?

The second focal discussion took place about the same time during the second year of data collection. This discussion was different in a few aspects. Most notably the students moderated turns in this discussion, which I took responsibility for in the first discussion. As a result there were more opportunities for students to call on friends. This also removed me from being a controlling participant in this discussion, which had benefits and drawbacks. The central point is that my relative absence in this discussion allowed students to determine the 'rules' for participation. As a result, this discussion seemed to include more shared utterances.

The discussion is represented in Figure 4.2 below. Using the same features as in figure 4.1, students' comments were removed, to focus on their actions in the discussion. Each large box represents a thematic sequence, with speakers represented inside these boxes. The smaller boxes do not represent specific utterances, but turns. The arrows represent shared utterances across turns. Solid arrows stay with in the thematic sequence, while dashed arrows represent shared utterances across thematic sequences. The grey circles number the thematic sequences to enable further discussion below. In the upper right hand corner a grey box is a key that explains abbreviations in the boxes.

Figure 4.2


START
Teacher Question Thematic Sequence (lines 1-28)
1
? Teacher question (1)
R Students' response (9)
SU Student claim(25-28)
NC Non-consenting student sequence
Student Initiated Thematic Sequence (lines 100-143)
2
SU Student revitalize (103-107)
SU Student claim (129-131)
SU Student claim (136-138)
SU Student claim (140)
Student Evaluation Thematic Sequence (lines 144-150)
3
SU Student evaluation (146)
R Student response (147-149)
Teacher Initiated Thematic Sequence (lines 150-195)
5
A Teacher uptake (159, 164)
? Teacher question (168)
R Student Response (171)
? Teacher question (172)
R Student response (179-181)
SU Student uptake (189-195)
Student Evaluation Thematic Sequence (lines 200-230)
6
SU Student evaluation (201-202)
R Student response (204-218)
SU Teacher revoice (225)
R Student response (227)
Teacher Initiated Thematic Sequence (lines 230-237)
7
? Teacher question (232)
R Student response (234-236)
FIGURE KEY
? = question
R = Response
I = Initiation
SU = Shared Utterance
A = Alignment
E = Evaluation
S = Summary
FINISH

This focal discussion looks quite different from the wind and kites discussion when presented in this format. However, it did begin (circle one) similarly with a teacher question. The difference was that students took up the question with more than nominal answers (see transcript and further analysis below).

The next two thematic sequences were primarily filled with student talk. One reason for this was that students determined who spoke by calling on one another to speak. I was present in these (see transcript in Appendix A), however this primarily served to urge students to call on the next speaker.

In the second thematic sequence (circle 2), Rodger initiated the thematic sequence by drawing on shared utterances from a non-consenting student. Rodger claimed that the seeds people plant grow into plants. The ideas that seeds grow and that humans are vital in plant growth became a shared utterance used by a number of students. In line 140 (circle two), Annie summarized comments and simultaneously removed references to humans. While her comment, unlike several others in this thematic sequence, did not get used by peers directly, it did introduce a transition in the discussion.

Another interesting thing happened at circle three. Brittany evaluated Erin's claim (line 146). Her evaluation and challenge was about specific aspects of the claim, which was resolved easily. Later, at circle six, Rodger attempted to copy Brittany's approach (line 201-202). This is interesting because Rodger attempted, though unsuccessfully, to share the structure that Brittany used to challenge Erin and embed in the Annie's utterances.

Participation in other selected discussions

The focal discussions were selected because they included the greatest percentage of student involvement and the greatest number of shared utterances. However, across the remaining selected discussions patterns in shared utterances leading to participation were similar to those described above. Namely this was that students relied on shared utterances to either modify or extend on a prior statement, to connect a new utterance with those already shared, or to challenge the claims of a peer (this happened only twice in all of the coded utterances).

Students participated in accounts sharing utterances that involved human agents acting in the world.

One pattern that emerged in the data was that students' participation was greatest when jointly constructing accounts that involved human agents acting in the world. The general pattern was that students began by describing their experiences in the world and ways that they successfully controlled phenomena through their own or others' actions in the world. The result was that students developed accounts that sound like practical explanations of ways to do things. Occasionally students managed to abstract general principles to make more decontextualized statements, but ultimately this was not a frequent occurrence.

The following section again presents detailed descriptions of the ways that this pattern can be seen in the focal discussions. In addition, there are times presented that describe students' abstraction of decontextualized statements. However, it will be seen that these are infrequent. At the end of the section, I

provide further descriptions of students' participation in the remaining selected discussions.

Wind and Kites

In this first focal discussion, I initiated the topic by asking students to answer my questions about flying kites. Participation in this portion of the discussion triadic dialogue involving a teacher question, followed by a student answer, and then the teacher responds with evaluation of the student response. The consequence was that students did not participate in joint construction of accounts.

Line	Speaker	Utterances	***Commentary***
1.	Mr. E.	What has everybody been playing with that is so exciting and always want to take out at recess when we go outside^	*nominal question with one correct answer*
2.	Darrel	kites	*answer*
3.	Marquisha	kites	***shared utterance*** *answer*
4.	Mr. E.	How do those kites work?	*Redirect answer as question*
5.	multiple	WIND	*Answer*
6.	Mr. E.	Tell me a little more	*Redirect for further explanation*
7.	Mr. E.	I mean just the wind doesn't tell me how the kite works	
Classroom management; thematic sequence maintained			
12.	Mr. E.	Bobby / how	*question*
13.	Bobby	the string	*Answer*
14.	Mr. E.	What about the string^	*Redirect answer as question.*

The focus was on my questions and goals for students, with only one shared utterance. It is unclear whether that was intended to repeat the idea or just two

students with the same idea in succession. To maintain my focus I redirected each student answer as a new question. However, my questions in lines four, seven, and fourteen, were sufficiently open to allow students more than single word responses. Yet students' single word answers implicitly supported my control and attempted to appease my requests.

It is interesting to note that in line eight, there was some disorder, when I evaluated and redirected multiple students' collective claim "wind." One interpretation is that students were confused about my redirection and unsure about what would count as an adequate response. Another interpretation is that this sequence was not allowing them to pursue accounts they found meaningful and useful, and thus they resisted the focus I established in the discussion.

Next, Marquisha initiated a new topic by drawing in prior ideas about the importance of the string and wind. However, she altered the discussion focus; her claim rested on human agency as the central cause in kite flight.

Line	Speaker	Utterances	***Commentary***
21.	Marquisha	The reason how a kite flies *audio disruption*	***initiates*** *talk about causes*
22.	Marquisha	*beginning in middle of utterance* you make it	*introduces a human agent*
23.	Marquisha	and then put the string and stuff on it	***shared utterance*** *'string' including it in actions of agent*
24.	Marquisha	you get the string and you wind it in a big ball	*restates 'string telling human actions on string*
25.	Marquisha	and you hang on to it	*human agency; 'it' represents the string*
26.	Marquisha	and then you just run	*human agent acting*
27.	Marquisha	and it goes up in the air by the wind	*shifted 'it' to kite;* ***shared utterance*** *of wind*
28.	Marquisha	the wind blows and goes up in the air	*restate wind telling how*

Line	Speaker	Utterances	*Commentary*
29.	Marquisha	and it's flying	*restate (line 21) 'kite flies' = 'it's flying*
30.	Mr. E.	OK you've told me a good story about how	*evaluation of claims*
31.	Mr. E.	But I still don't understand how the kite is flying	*redirect by 'it's flying' = 'the kite is flying' as implicit question*
32.	Marquisha	It just flies	*response to implicit question; restate*

Marquisha's focus on human agency shifted the focus of the discussion. The result was this reads like a pushing match for power in the discussion. My evaluation and redirection (lines 30-31) implied a question that attempted to change the focus away from human agency to material objects acting in the world independent of human action. I used "OK ... but" and then shared "flying" from Marquisha to reject human agency and shift to claims that did not involving human agency. Marquisha responded (line 32) without referring to human agency; but implied, using "just flies," that my focus on material objects and causes was 'just' something that happens and not relevant to her claims or the account she would find meaningful and useful. Marquisha's response (line 32) avoided human agency. But her restatement of 'flying', which described conditional action, shifted to 'flies', which focused on action. This left the possibility of a human agent making the kite fly without explicitly stating it.

This was followed by a break caused by student interruption. After five lines I managed to yield the floor to another student. She revitalized Marquisha's focus, using shared utterances about human agency, which she combined with claims about material objects.

Line	Speaker	Utterances	*Commentary*
38.	Lora	The wind /	***Shared Utterance** wind*
39.	Lora	the string controls the kite	***Shared Utterance** string, adds a function for the string*
40.	Lora	so when you want to move it in different directions you have something to make it move in different directions	*Revitalize human agency claim, connecting this to the string function*
41.	Mr. E.	So the string sort of helps you to control the kite^	*Redirect; **shared utterance** human agency claim to follow the thematic sequence*
42.	Mr. E.	Is that what you said^	*Invitation to respond*
43.	Mr. E.	Just a minute Rodger	*Request; response to bid to speak*
44.	Lora	If you want to fly a kite you have to have string	*Restate human agency claim, including string*
45.	Lora	When you have string it doesn't make it fly away	*Reformulate function of the string*
46.	Mr. E.	OK	*Acknowledgement*

Lora revitalized attention on human agency, which established a connection with Marquisha, while making claims (lines 38 &39) that matched my desires for the account. My redirection in line 41 only asked her to confirm her claims. Potentially her inclusion of utterances consistent with my wishes made me avoid challenging her like I did with Marquisha.

Following this, I used meta-linguistic utterances to model ways to agree and disagree in discussions for students. I use meta-linguistic to refer to my statements that told students about acceptable ways to talk in the discussion, but did not add substantively to the discussion. The result of this move created a break in the ongoing activity that allowed another student to initiate a new topic. This new topic also described human control over phenomena.

Line	Speaker	Utterances	*Commentary*
58.	Rodger	The string control the kite because for the kite to stay up in the air	***Shared utterance*** *string and kite, talking about the functions of those things*
59.	Rodger	First they make it out of wood	*Initiates talk about methods used by impersonal "they"*
60.	Rodger	Then they get a / make a T or something	*Methods continued*
61.	Rodger	Then / like those other kites / they just have a little bit of thing	*Adds characteristics*
62.	Rodger	Then the last time had one of those / mine fall apart	*Tells about a personal experience flying kites*

Rodger, sharing utterances from prior speakers, described the functions of the string, which connected him to the developing account about human agents acting. This should have positioned his utterances as part of the group's jointly constructed account of flying kites. However, others did not share his claim. Failure to have his ideas to become taken as shared positioned Rodger uniquely in the discussion context. He attempted to be a contributor, but failed to do have peers see his contribution as meaningful or useful. The question is whether this was because of his shifting from flying to making kites, or whether it was in response to his status in the classroom[10].

At the end of Rodger's turn a new topic was initiated. I drew a picture on the board to represent my question. The drawing scaffolded student claims and established a thematic sequence that related wind and kite flight. The following selection picks up after the drawing was complete.

[10] Social status affecting shared utterances may be very important. However, this study did not focus on the relationship between students' status and their peers sharing their utterances.

Line	Speaker	Utterances	***Commentary***
92.	Mr. E.	Which direction is the wind blowing^	*Restate from line 78*
93.	Kelvin	this way	*claim*
94.	Mr. E.	Which is this way^	*Redirect using* ***shared utterance*** *(line 93)*
95.	Mr. E.	Is it blowing this way^	*Restate (line 94)*
96.	Mr. E.	*draws on board* is it blowing like this^	*Restate (line 95)*
97.	Kelvin	its this way *gesturing*	*repeat or shared utterance (line 93 OR 96)*
98.	Darrel	naa /	
99.	Darrel	its blowing that way	***shared utterance*** *counterpoint (line 97)*
100.	Mr. E.	So I should have my arrow pointing over here^	*reformulate (line 99)*
101.	Darrel	yes	
102.	*multiple*	*overlapping talk*	

This continued for the remainder of the discussion. There are two possible interpretations described here. One is that I dominated the discussion, convincing students to follow my desires and develop a set of claims that related wind and kite flight. A second interpretation is that students and I were jointly constructing, in this portion of the discussion, claims about relationships between wind and kite flight. I argue that given the interchanges between speakers, that so many students and I were in the same "psychological time/space" (Edelsky, 1993) that this is more likely an instance of joint construction in which we participated in using shared utterances and claims. Furthermore, in the final line of the transcript, once it was clear that students did not agree, I suggested that this was something to check out. Thus I did not evaluate or judge their ideas, but was jointly involved with them in understanding this particular phenomenon.

What are seeds?

The second focal discussion was also initiated by a question I asked; I asked students to define seeds. The following transcript begins after I asked the question, provided instructions about norms, and yielded the floor to Annie.

Line	Speaker	Utterances	***Commentary***
9.	Annie	It's something that grows into a plant	*Initiate topic as growth relationship*
10.	Mr. E.	OK *opens journal to make notes*	*Acknowledgement*
11.	Annie	Isaac	*Invitation to speak*
Interruption as I negotiate with students about using science journals.			
25.	Isaac	A seed is like / is s... / is something /	***Shared Utterance** (is something)*
26.	Isaac	is something that before it it's a plant /	***Shared Utterance** (plant) supports prior claim using different structure*
27.	Isaac	like it's a flower or a like tree	
28.	Isaac	it starts out as a seed	*Restate – return to idea*

Initially Annie makes a claim about seeds growing into plants (line 9). What remains unclear is what conditions are required for growth. There are a range of possibilities, but this initiates a topic that students could share. Isaac used a shared utterance to connect his ideas with claims made by Annie. However, his claims added detail in terms of a plant being 'a flower or a tree' and avoided the conditional claim about growth. Furthermore, his claim actually fit the nature of the question better than Annie's claim. She described seeds growing, which does not define seeds. Isaac generated an utterance that sounded more like a taxonomic statement that related seeds to their adult

counterpart. Thus, he used the same ideas, but revised the claim to sound more scientific.

Following this there was an extended discussion, lasting 81 lines of transcript, which focused on claims from a non-consenting student. While these utterances are not examined, they were important in the discussion because they led into subsequent utterances (that included primarily consenting students) that described planting and growing seeds. This was important because it established important claims that continued throughout the discussion. For example, Rodger picked up on the idea and implicit experience of planting seeds:

Line	Speaker	Utterances	***Commentary***
103.	Rodger	I got like some real big seeds	
104.	Rodger	And if you dig a small hole	***Shared Utterance*** *NC student talked about planting seeds*
105.	Rodger	that won't work for it	
106.	Rodger	if it is a real big seed	
107.	Rodger	you got to dig the hole real deep so it will grow good	*Initiates topic about requirements for growth*
Sequence of non-consenting student turns			
129.	Breanne	A seed even grows into a plant	***Shared Utterance*** *line 9*
130.	Breanne	First it has leaves	*Continues adding information about stages of plant growth*
131.	Breanne	and the green little plant comes from the seed but it also comes from the stem too	
132.	Mr. E.	OK a couple more people are still waiting	*managing talk*
133.	*multiple*	*overlapping talk*	
134.	Mr. E.	quickly	*request*
135.	Breanne	Erin	*invitation to speak*
136.	Erin	First you plant the seed	***Shared Utterance*** *steps in planting seeds*

Line	Speaker	Utterances	*Commentary*
137.	Erin	and when you give a seed water it grows into a plant	***Shared Utterance*** *seed needs for growth and line 9*
138.	Erin	and you keep on watering it and then it grows into a flower	*Restate self*
139.	Erin	Annie	*invitation to speak*
140.	Annie	A plant seed / a seed needs water / light / and umm dirt	***Shared Utterance*** *takes up several preceding ideas and synthesizes, adding new information*
141.	Mr. E.	OK now we are talking about the things a seed needs	***Shared Utterance***

These utterances were not only important in for including many ideas that students continued to talk about, it also included several speakers, all using shared utterances to participate in joint construction. Rodger built (line 104), using a shared utterance, a claim that integrated human agency and introduced the notion of seeds requiring certain things for plant growth. Implicit in this was that human agents were required for plant growth. Subsequently, Breanne talked about plant growth (lines 130-131), sharing the early definitions of seeds by Annie and Isaac (line 129). This was only important because following Breanne, Erin continued (line 136), connecting to Breanne and Rodger, that plant seeds also need humans to provide the seeds water.

A slight shift occurred when Annie drew on shared utterances, adding that plants need light (line 140). However, her claim shifted out of statements of human agency, while retaining clear connections to peers. It was almost like Annie wanted to summarize the claims similar to what a teacher does in a revoicing move (O'Conner & Micheals, 1996). This effectively shifted the

discussion from being about human agents acting, to generalizable phenomena in the world.

Following this, one student evaluated another's claim. Brittany used a shared utterance to challenge Erin saying, "not all seeds grow into flowers (line 146)." Erin acknowledged this and replied, "flowers, plants, and other kinds of stuff (line 149)." Both girls connected their assertions with prior claims. Furthermore this shows an explicit instance when students jointly constructed a more complete, though not entirely complete, claim about seeds and plants.

Following this there were a few turns from a non-consenting student. In these turns an idea comes up that must be mentioned, without analysis. The student commented about seeds being in food. This led to my bid for the floor, by raising my hand as any speaker would, and initiating a new topic in the form of a question. I wanted to know 'where do seeds come from?' Students used shared utterances to respond to this question. It is important to note that my question allows for either a scientific explanatory framework (describing reproduction) or a practical framework (describing where and how human agents obtain and exert control over seeds). The turns in portion of the discussion were broken with both non-consenting student speech and management interruptions. However the main points include the following excerpts.

Line	Speaker	Utterances	***Commentary***
170.	Mr. E.	Isaac / where do seeds come from?	*Initiate seed origins*
171.	Isaac	Nature	*response seed origins*
172.	Mr. E.	But where in nature^	*Redirect* ***Shared Utterance*** *nature*
Isaac struggles, Mrs. C. asks him to repeat, and then the turn shifts			

Line	Speaker	Utterances	*Commentary*
179.	Beverly	They grow on kinds of trees	***Shared Utterance*** *seed origins*
180.	Beverly	and then fall	*Extend seed origins*
181.	Beverly	and sometimes they fall on the dirt	***Shared Utterance*** *seeds grow in dirt (line 140)*
Minor management; Beverly yields to Annie			
189.	Annie	Trees have *audio glitches*	***Shared Utterance*** *trees*
190.	Annie	If you got a tree seed and you want to grow it	***Shared Utterance*** *seeds grow into trees (line 27)*
191.	Annie	and that tree grows seeds	*Restate line 127*
192.	Annie	and umm and it	
193.	Annie	they get to little seeds and sometimes those little seeds grow into food	***Shared Utterance*** *NC student idea that there are seeds in food*
194.	Annie	and the food drops and some of the seeds come out	*Restate line 181, adding that fruits fall containing seeds.*

The students used shared utterances to jointly construct claims and an account. My initial question was similar to the nominal question I asked in the kites and wind talk. However, in this case students effectively worked within my question to develop answers that were went beyond nominal responses. It is interesting that Beverly drew on an idea from Annie in line 181, implying that seeds need to be in dirt to grow. Then Annie returned to share an utterance with Beverly in line 194. Annie also included ideas from a non-consenting student. This is interesting because the student whose idea Annie took up was well-liked by other students, spoke often in discussions, and was one of the older students in the class. The joint construction between Beverly and Annie is also interesting

because these girls were not popular students in the class. So it was as if they shared a social benefit by sharing ideas of one another.

Next there was another evaluation; however it was not as simple as the first evaluation. Rodger jumped in (line 201), without permission, to challenge one of Annie's claims. His challenge is interesting in a few ways. First it is interesting to look at the nature of the challenge. Then it is interesting to consider the shared utterances he draws on in the challenge. Finally it is interesting to consider this in light of Annie's recent collaborations with Beverly.

Line	Speaker	Utterances	***Commentary***
200.	Rodger	Annie / I got a question for you	*Bid*
201.	Rodger	Like you said how would a all seeds grow into a umm flower	*Citation claims that Annie said seeds grow into flowers – NOTE: Repeats Brittany's challenge of Erice*
202.	Rodger	That's what you said	
203.	Annie	huh-uhh	*Disagreement with claim*
204.	Annie	Here's what I said	*Report*
205.	Annie	If you have a umm tree seed and you plant it and it grows and if has	*Restate lines 190-191*
206.	Annie	some trees have	*Restate*
207.	Rodger	I don't get it	
208.	Annie	then they grow little seeds on them	*Restate line 193*
209.	Annie	and then they grow food	*Restate line 193*
210.	Annie	and sometimes the food falls off	*Restate line 194*
211.	Annie	and it the seed	*Restate line 194*
Annie continues to restate all her prior claims, eventually she concludes to say that it is "like a lifecycle (line 218)." At this point I jump in.			

Line	Speaker	Utterances	*Commentary*
225.	Mr. E.	What I thought Rodger was saying was that it sounds like you are saying Annie that all seeds come from trees//	***Citation/Shared Uterance*** *interpretation of Rodger's challenge to Annie.*
226.	Mr. E.	Is that what you mean^	
227.	Annie	I just mean some seeds	*Acknowledgement*

Rodger attempted to mimic the strategy Brittany used to challenge Annie. Thus the nature of the challenge is one that should be successful since it was for Brittany. In fact, he almost used her words verbatim. However, it seemed unsuccessful and Rodger essentially gave up (line 207). The problem that Rodger faced was that Annie never in the whole discussion said anything about flowers. Thus Rodger may have had a logical challenge, which I interpreted for him in line 225, but he was unsuccessful given the inaccuracy of his challenge. His sharing of utterances needed to be from Annie's claims and then using Brittany's approach. This was essentially how I interpreted his challenge.

It is also interesting to consider why Rodger challenged Annie and if it was anything more that a coincidence that this came right on the heels of Annie's collaboration with Beverly. Early in the discussion Rodger made utterances that a number of students shared. It is possible that he was hoping for a similar status building opportunity in this challenge.

Finally I continued, after interpreting Rodger's challenge, to challenge Annie. I took an opportunity to revitalize my own questions (line 168). Rodger then jumped in (line 230), almost building an alignment with me.

Line	Speaker	Utterances	*Commentary*
228.	Mr. E.	Some seeds come from trees	***Shared Utterance*** *Beverly & Annie*
229.	Mr. E.	So where does	
230.	Rodger	*jumping in* Like what kind of	***Restate*** *unsure, possibly line 228*
231.	Mr. E.	Well maybe we don't need to know what kinds//	***Restate*** *line 231*
232.	Mr. E.	Like where do other seeds come from^	*Redirect* ***Shared Utterance*** *Beverly & Annie*
233.	Mr. E.	If not all of them come from trees where do other ones come from ^	***Restate*** *line 232*
234.	Annie	Stores sometimes	*Response*
235.	Annie	umm / I don't know what they come from	***Restate*** *line 234*

The main point is that Rodger jumped in during my question in line 229, attempting to collaborate with me in my question. My response again interpreted Rodger, but maintained that his question was not the one that I was asking. This is interesting because he allowed this similar joint construction by me a few moments earlier. It might be that he was attempting to build an alignment with my in order to develop a higher status in the class.

Summarizing, students were successful in using shared utterances to initiate and support participation. This allowed the students to jointly construct an account about seeds. There was limited evaluation of claims in the account, though never the whole account. Students had more opportunities in this discussion to enact social purposes. In contrast with the wind and kites discussion, I was a participant in the discussion, seeming to stimulate and support student discussion and thinking. Finally human agency was important in

students' jointly constructed account, including the planting and care of seeds to make them grow. However, students' use of human agency was less explicit, sounding more like examples.

Participation in other selected discussions

In the selected discussions, students followed similar patterns of participation. Students were most likely to share utterances that described human actions in the material world. When I, as the teacher, attempted to intervene in the topics of utterances or claims or when I attempted to direct the discussion by moderating turns there was a decrease in participation and joint construction. My interventions in topics attempted to abstract general statements about the world based on student utterances and claims. However, multiple students rarely participated in this abstraction. When students did participate in joint construction with me in abstract statements, the result was that these instances became moments of dyadic dialogue focusing on me and one student. Occasionally students jointly constructed together such abstract claims, however in those instances the common result was again a dyadic discussion.

Summary of participation

In this section I have focused mostly on participation of students and features that support participation. However, this does not identify the characteristics of those features that support students' joint construction. Therefore, it will help to understand the nature of the language that implicitly supported participation and joint construction. In order to do that, it will be necessary to look more closely at the thematic sequences identified in figures 4.1

and 4.2. The following section describes patterns in the thematic sequences that supported students' joint construction.

Language: How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?

To identify patterns in the language that students used required looking closely at each utterance to determine its meaning. This allowed patterns in the meanings that students attempted to construct jointly in different discussion contexts. Therefore this section first considers semantic relationships and thematic sequences (Lemke, 1990) that led to joint construction in the two focal discussions. Then it is possible to step back and consider whether these patterns are consistent across other discussion selections. Therefore subsections look at *Wind and Kites* and *What are seeds?* and then considers *Patterns in selected discussions.*

Semantic relationships and thematic sequences supported joint construction of accounts

Recall from Chapter Two that semantic relationships describe the ways that words in an utterance relate to one another and ultimately result in the utterance having meaning. Furthermore, based on coding of semantic relationships in utterances, it is possible to identify themes that occur in those

utterances[11]. These constructs are used here to identify patterns in students' joint construction.

Wind and Kites

Recall that this focal discussion was about wind and kites. The discussion took place on May 15, 2001 near the end of a unit on weather. Students had experiences playing with kites at recess. They also used wind vanes to describe wind direction. There are some important things to notice regarding initial assertions and joint construction. Analysis of initial assertions focused on utterances to identify semantic relationships within students' utterances. Analysis of joint construction focused on thematic sequences to examine how semantic relationships and thematic sequences supported students' development of accounts[12].

Table 4.1 summarizes, including quoted utterances, the semantic relationships in utterances that led to thematic sequences and ultimately knowledge claims in this discussion. The focus in Table 4.1 is on the utterances that become taken as shared and used in joint construction of knowledge claims. The complete transcript is found in Appendix A; however as necessary in the following description, longer quotes from the transcript are used to clarify the points. Elaboration on these findings will follow the table.

[11] Semantics and thematics are more completely described in Chapter 2. Their use in coding is described in Chapter 3 along with further details in Appendix B

[12] See Chapter Three for definitions and explanation of these analytic constructs.

Table 4.1 – Semantic Relationships and Thematic Sequences in Wind and Kites Talk

	Line	Selected Utterances	*Semantic Relationships*	*Thematic Sequence*	*Knowledge Claim*
1.	1-16	Teacher: How do those kites work?	*object/ process*	*process*	*The question implies a process explanation of kites*
2.		multiple: WIND	*medium*		
3.		Teacher: Tell me more about that, just wind doesn't tell me how kites work.	*object / process*		*Request for complete semantic relationship*
4.		Bobby: string	*object*		
5.		Teacher: What about the string?	*object / process*		*Request for complete semantic relationship*
6.	21-32	Marquisha: The reason how a kite flies ...[is] you make it	*object / process agent / action*	*human agency* *dependent processes*	*Assert that human actions make kites fly. 'You' reminds listener or creates an experience.*
7.		Marquisha: You get the string and you wind it in a big ball, and you hang on to it, and then you just run	*agent / object agent / action agent / action*		*Elaboration that structures are required but acted on by humans. Steps describe patterns of events.*
8.		Marquisha: And it goes up in the air by the wind; the wind blows and goes up in the air. And it's flying	*connector object / process medium / process object / attribute*		*Assert that the wind make the kite fly into the air. Pattern, with possibility of explanation, but relies on prior human agency.*

	Line	Selected Utterances	*Semantic Relationships*	*Thematic Sequence*	*Knowledge Claim*
9.		Mr. E.: But I still don't understand how the kite is flying	*object / process* *object / attribute*	*process*	*Evaluation seeking independent explanation*
10.		Marquisha: It just flies	*object / process*		*Re-assert that the kite flies, emphasis that how is not important implying that actions of the agent are important.*
11.	39-45	Lora: The wind, the string controls the kite.	*medium* *object / process*		*Elaborate on functions of structures. Pattern or experience*
12.		Lora: So when you want to move it in different directions you have something to make it move in different directions.	*agent / action* *agent / object* *object / process*	*human agency*	*Assertion of the human agent presented in an example experience to describe a function of a structure.*
13.		Mr. E.: So the string sort of helps you to control the kite?	*object / process* *agent / action*		*Redirect to clarify knowledge claim about human agency.*
14.		Lora: If you want to fly a kite you have to have string. When you have string it doesn't make it fly away	*agent / action* *object / process* *medium / process* *object / attribute*		*Patterned understanding of function of the structure that a human agent would use*

	Line	Selected Utterances	*Semantic Relationships*	*Thematic Sequence*	*Knowledge Claim*
15.	58-62	Rodger: The string control the kite because for the kite to stay up in the air.	*object / process object / attribute*	*process*	*Restated from above, shifted semantics and thematic avoiding human agency.*
16.		Rodger: First they make it out of wood. Then they get a, make a T or something. Then, like those other kites, they just have a little bit of thing.	*agent / action*	*human agency and design*	*Asserts description of design elements in construction Pattern or experience*
17.	78 - 100	Mr. E.: Which direction is the wind blowing^	*medium/ manner*	*circum-stances*	*Question implies description of manner of wind movement*
18.		Kelvin: this way	*manner*		*Assertion about wind direction in drawing*
19.		Mr. E.: Which direction is this way?	*manner*		*Question to scaffold description*
20.		Kelvin: its this way *gesturing*	*manner*		*Elaboration using gestures*
21.		Darrel: its blowing that way	*manner*		*Counter assertion about wind direction in drawing*
22.	108-125	Mr. E.: OK So we all know that the wind is blowing that way	*medium / manner*		*Summarize claim*
23.		Lora: The wind goes anyway it wants.	*medium / action*	*agency*	*Attributed agency to inanimate medium*

	Line	Selected Utterances	*Semantic Relationships*	*Thematic Sequence*	*Knowledge Claim*
24.		Mr. E.: But in this picture, in this situation, we all agree that the wind is going this way.	*medium / manner*	*circum-stances*	*Clarify and restate claim*
25.		Felicity: It goes this way.	*medium / manner*		*Elaboration on claim*
26.		Mr. E.: Felicity says the wind is going this way	*medium / manner*		*Repeat elaborated claim*

In the opening thematic sequence (Rows 1-5, Table 4.1), I posed questions to the class, asking students for explanations about kites flying. Students' single word responses could not be coded for semantic relationships since semantic relationships seek to explain the meanings that relate two or more words. It might be possible to infer the intended semantic relationship for a single word utterance. For example "wind" could be interpreted as 'wind makes kites fly' or 'kites fly in the wind'; however, these two examples express different relationships. Thus it is difficult in this situation to determine what claim students were making in these utterances. However, the utterances are important because the objects of students' single word responses, wind and string, became important as the discussion continued.

The opening thematic sequence (rows 1-5) does not contain joint construction. My questions to students implied thematic sequences about processes. However, students' nominal responses did not include complete semantic relationships. In response, I continually asked students for elaboration,

while they continued to make nominal single word utterances. I think students were not engaged in the thematic sequence that I attempted to establish and as a result no joint construction occurred.

Marquisha's utterances, beginning in Row 6, initiated a different thematic sequence by describing an indefinite "you" doing something to create an outcome. It was clear that she talked about phenomena in the world. However, her statements did not fit Lemke's (1990) framework of semantic relationships. Therefore, analysis and examination of data needed to look more closely at Marquisha's claim to explore the nature of her utterances. She said,

> The reason how a kite flies [is] you make it. Then put the string and stuff on it you get the string and you wind it in a big ball. And you hang on to it and then you just run and it goes up in the air by the wind. The wind blows and goes up in the air and it's flying.
>
> (lines 21-29; May 15, 2001)

This turn might be readily dismissed, as not offering claims relevant to the development of an account of kites flying. However, her utterances were shared by her peers, which suggests it had meaning for students. Marquisha focused on the actions of an indefinite you. The central semantic relationship of her claim becomes one relating agents[13] and their actions. In this case Marquisha's claims could be characterized as focused on human agency. She described processes of the human agent enacts to exert control over phenomena in the world; thus establishing a new thematic sequence. Later in her turn, she makes statements

[13] Lemke does refer to agents in his descriptions of semantic relationships. But this is different than human agents. Since this kind of statement was prominent in the transcripts, I have used agent only to refer to instances of human action and all other subjects (nouns) became objects.

about interactions of phenomena; however these are contextualized as resulting from her statement of human agency.

In row 11, Lora took up the processes that Marquisha attributed to human action, referring to these processes devoid of human agency. But she did not complete this turn without returning to connect with the animated human actor. Lora's move allowed her to synthesize utterances across turns. She included the human agent in an action, directly connected to a decontextualized statement about objects and processes. This connected these semantic relationships, making clear the connection students made between agent and object. This was joint construction because it drew on two semantic relationships (attributable to Marquisha in row 7 & 8) and comments about wind and string (rows 2 and 4). Furthermore, she constructed this statement in a logical 'if-then' statement that sounds scientific and using a model-based structure, but it was based on semantics that were about practical action in the world. In this joint construction, the students focused on the role of the human agent, thus their shared thematic pattern considered human agency.

The next claim relied on preceding speakers. Rodger, in Rows 15 and 16, describes design features of kites. Rodger, like Marquisha, relied on human agency, but focused on features of kites and making kites. Thus the semantic relationship of this assertion focused actions of human agents in design. This recognized patterns of performance and efficiency suggesting that different materials or designs function better than others. However, Rodger shifted the semantic relationship focused on human agents exerting control over

phenomena to human agents as designers of objects. The shifted the semantic relationships probably contributed to the result that Rodger's utterances were not taken as shared by the group.

The semantic relationships of students' utterances in the final thematic sequence were difficult to clearly interpret. As in the first sequence, multiple students made partial utterances. Thus the claims associated with these utterances are also unclear. In addition, the thematic sequence included the use of a representation of a phenomenon. I drew a picture of a person and a kite on the board and asked students to describe the wind direction relative to the picture. This led to several statements like, "this way" and "that way" (see rows 17 -20), which included gestures and references to the drawing. Such statements alone do not include semantic relationships (though they do include semiotic relationships). However, in the context, including gestures and the drawing, the utterance can be interpreted as, 'the wind blows toward or away from the kite in that picture.' This made a semantic relationship between wind (a medium) and its direction (manner) toward or away from the kite. Thus the claims were the wind blows toward the kite or the wind blows away from the kite[14].

In row 23, Lora returned to the shared interest in agency, attempting to initiate a thematic sequence by anthropomorphizing that wind 'wants' to move in different directions. Her utterance included a semantic relationship that ascribed desire, typically a human characteristic, to inanimate media, wind. This utterance

[14] These exact points are not included in the table because the table referred only to the utterances in the transcription.

came in the middle of several utterances that were developing semantic relationships describing circumstances of wind direction related to kite flight. Thus Lora's assertion was not consistent semantically with the on-going discussion, like Rodger in rows 15 and 16. Furthermore, this utterance did not become taken as shared, since no other students used the idea that wind can want something. So while agency had been a thematic pattern earlier in the discussion, the discussion had shifted. Lora's entry into the new thematic sequence failed because her claims were not semantically relevant to the developing thematic sequence.

Regardless, I consider the thematic sequence occurring in rows 17-26 a second example of joint construction. These utterances attempted to describe the conditions present in a hypothetical situation of flying a kite. The students (based on my questions) were trying to say which direction the wind blew in relationship to the kite flying, all related to a representation. I operated within their utterances, attempting to support their claims about wind direction by scaffolding their claims with questions and the drawing. Furthermore, my role, of asserting a relationship using a representation, situated me as a participant in the discussion. The students and I were jointly constructing a claim about the nature of the relationship between wind direction and kite flight.

The drawing played a vital role in this discussion, essentially becoming a claim in the discussion context. Without the drawing, students needed to connect experiences with kites to knowledge, translating this to a related utterance about the wind, the kite and its position relative to the wind direction.

With the drawing the semantic relationship in my question could be a nominal question that focused students on an assumed phenomenological relationship; that wind affects kites. Since the question was nominal, students' responses were also nominal, saying 'this' or 'that' way. However, in this context the utterances became part of a thematic pattern focused on the circumstances needed for kite flight. The drawing represented utterances in the thematic sequence for students so that they could participate in joint construction without sophisticated language to develop independent utterances consistent with preceding semantic relationships.

In summary, this discussion began with incomplete utterances suggesting that wind and string were important in kite flying. Marquisha integrated these ideas into claim about the ways that human agents exert control over structures (string) and media (wind) to fly a kite. Rodger claimed that human actions design kites in particular ways. I implied that kites fly in only particular circumstances related to wind direction, which led to students making, but not agreeing on, claims about the direction of the wind relative to the flight of the kite. Finally, Lora's claim ascribed agency to wind.

Two important findings from this focal discussion provide insight into the ways students talked about content in this discussion context. First, students' joint construction initially relied on human agency. This facilitated joint construction because it afforded the introduction of students' own lived experiences. Second, students could, during the portion of the discussion about the drawing, jointly construct claims that described conditions for kite flying

without direct reference to human agency. However in this instance such joint construction relied on a drawing to support students making semantically connected utterances that fit the on-going thematic pattern. Finally, students' jointly constructed account agreed only on the actions of human agents to exert control over phenomena. Claims about phenomena occurring beyond the control of humans were present in the account, but not agreed on by all students.

What are seeds?

This focal discussion was about seeds and plants growing from seeds. It took place late in Year Two as part of a unit on living things Table 4.2 summarizes the semantic relationships of utterances and indicates how utterances were part of thematic sequences to develop knowledge claims and accounts of plants and seeds. The complete transcript of the discussion is included in Appendix A; however as necessary in the following discussion, longer quotes from the transcript are used to clarify the points. Elaboration on these findings will follow the table.

Table 4.2 – Semantic Relationships and Thematic Sequences in Seeds Talk

	Lines	**Selected Utterances**	***Semantic Relationships***	***Thematic Sequence***	***Knowledge Claim***
1.	1-28	Mr. E.: What is a seed?	*attribute / object*	*classify*	*Question implies defining attributes of seeds*
2.		Annie: It's something that grows into a plant	*object / process*	*process*	*Assertion that seeds are defined by growing into plants*

3.		Isaac: A seed like is something, is something that before it it's a plant, like it's a flower or a like tree, it starts out as a seed.	*object / class class / example event / object*	*classify*	*Assertion that classifies seeds according to a the class plants; uses examples to develop class*
4.	29 -100	*Extended sequence of non-consenting student speech*			
5.	100-143	Rodger: I got like some real big seeds.	*object / attribute*	*classify*	*Report to establish validity*
6.		Rodger: And if you dig a small hole, that won't work for it if it is a real big seed	*agent / action action / outcome*	*human agency*	*Assert that seeds need appropriately sized holes to grow when planted by human agents*
7.		Breanne: A seed even grows into a plant.	*object / process*	*process*	*Re-assert definition of seeds as growing into plants*
8.		Breanne: First it has leaves and the green little plant comes from the seed but it also comes from the stem too.	*object / event object / process*		*Elaborate describing stages of seed growth*

9.		Erin: First you plant the seed.	*agent / action*	*human agency* *dependent processes*	*Elaborate on human agency (row 6)*
10.		Erin: And when you give a seed water it grows into a plant.	*agent / action object / process*		*Assert agent actions of watering seeds is a process that plant growth depends on*
11.		Erin: And you keep on watering it and then it grows into a flower.	*agent / action object / process*		*Repeat making the plant become a flower*
12.		Annie: A plant seed, a seed needs water, light, and umm dirt.	*object / conditions*	*circum-stances*	*Summarize assertions of action dependent processes necessary for growth*
13.	144 – 150	Brittany: Erin, not all seeds grow into flowers	*class / object*	*classify*	*Validation of assertion focused on classification*
14.		Erin: Yes, flowers and plants and other stuff	*class / object*		*Acknowledge and elaborate on classes*
15.	150-195	Mr. E.: Everybody agree [s] that a seed grows into a plant	*object / process*	*process*	*Summarize process definition of seeds*
16.		Mr.E.: Isaac, where do seeds come from?	*object / origin*	*circum-stances*	*Question about the origins of seeds*

17.		Isaac: Nature	*location*		
18.		Beverly: They grow on kinds of trees and then fall	*object / origin*		*Assertion that seeds grow on trees and then fall*
19.		Beverly: And sometimes they fall on the dirt.	*object / event*		*Elaborate that the seeds that fall can fall on dirt*
20.		Annie: If you got a tree seed and you want to grow it and that tree grows seeds.	*agent / process*	*human agency* *dependent processes*	*Assert agent actions produce the seeds by making a tree grow*
21.		Annie: They get to little seeds and sometimes those little seeds grow into food	*object / process event / process*	*processes*	*Elaborate on claim, devoid of agency that seeds grow in fruit on trees*
22.		Annie: And the food drops and some of the seeds come out.	*object / process object / process*		*Repeat sequence involving fruit*
23.	200-230	Rodger: Annie how would a all seeds grow into a flower	*object / class*	*classify*	*Evaluation of prior assertion; confused speaker and claim*

24.		Annie: If you got a tree seeds and you want to grow it, that tree grows seeds	*agent / action*	*human agency*	*Elaborate adding the role of human agent necessary for planting seeds*
25.		Annie: Some trees have seeds that grow fruit and fall … it will start all over again like a life cycle	*object / class object / event*	*classify*	*Elaborate that some trees grow fruit (some is classifier); add concept that plants and seeds follow a pattern of lifecycle*
26.		Mr. E. : I thought Rodger was saying that it sounds like you are saying all seeds come from trees	*object / class*		*Revoice student evaluation to clarify that the issue is that not all seeds come from trees.*
27.		Annie: I just mean some seeds	*object / class*		*Respond to evaluation*
28.	230 - 237	Mr. E.: Where do other seeds come from?	*object / class object / origins*	*circum-stances*	*Re-state question about the location on the object that seeds*
		Annie: Stores sometimes	*origins*		

Annie's utterance (row 2) responded to my question, "What are seeds?" The question implied that the response should involve a definition or classification. Annie said that seeds grow into plants. While this could be semantically interpreted as a definition, the thrust of her utterance was seeds grow to make new plants. Her utterance focused on processes or actions that the seed completes, and thus was semantically a statement of process. Building on Annie, the next utterances shifted the semantic relationship to classify or identify things as members of a group. Logically, to classify something, one often relies on characteristics of a class or identity attributes. The following quote shows a claim that classified the object.

line	Speaker	Utterance	Semantic Relationship	Commentary
25.	Isaac	A seed is like / is something /	*object / class*	*The student first identified the thing he classifed.*
26.	Isaac	is something that before it it's a plant /	*object / event class*	*He classified the object related to other objects; plants were the class.*
27	Isaac	like it's a flower or a like tree	*class / example*	*The class 'plant' was elaborated using familiar examples.*
28.	Isaac	it starts out as a seed	*object / object*	*Then he returned to the object, reconnecting it and the class.*

5-13-02(2)

Isaac essentially said, 'a seed is something that before it's a plant it's a seed.' To begin with, each utterance paralleled either the subject or the phrase preceding it. He began with 'a seed' and ends with 'a seed'. He parallels 'plant' with a phrase that includes 'flower' and 'tree' as examples. Therefore he took some effort to compare the object and the group to which this object belongs.

Another way that this selection is interesting is that it draws on a shared utterance, namely when Annie claimed that, "it's something that grows into a plant (line 9, 5-13-02(2))." Isaac essentially elaborated on Annie's utterance. However, while he interpreted, and re-stated Annie's utterance, he made important alterations that asserted something different. He clearly broke apart the object of observation, the seed, from the group to classify, plants. In addition, he elaborated on the group providing examples. Thus his utterance distinguished seeds from plants, while still recognizing a fundamental relationship between them. In contrast, Annie's utterances could be interpreted as claiming that seeds grow into plants and thus are parts of the whole.

Some students' utterances failed to follow semantics of preceding statements. An interesting example of this occurred in this selection. In table 4.2, row 3, Isaac claimed that 'a seed was something that before it was a plant it was a seed (paraphrased).' He added examples of plants, saying they were 'flowers or trees.' The core of his utterance did not semantically relate seeds growing into plants as an action of seeds. Instead his relationship described before and after outcomes. Fundamentally the outcome was the same, but it was interesting to see that 'before and after' semantics were not used by other

students. Breanne, in row 8, used sequences, which might have led to similar 'before and after' relationships. However, she focused on growth and the outcomes of growth. A final point about the utterance in row 3, it is interesting that students only referred to flowers and trees as kinds of plants in this discussion, even though they had experiences with more types of plants[15]. So while, Isaac's utterance did not become an important semantic relationship for students, they seem to have taken portions of his idea.

In row 6, Rodger described how to plant a seed. He began using a human agent, which established a thematic pattern using human actions in the world. Then as if coaching the listener, he described particular actions that 'you' needed to take, so the seed could grow well. Breanne joined the thematic sequence and drew from a prior utterance (row 2) repeating that seeds grow into plants. She then shifted to talk about stages of plant growth. In row 9, Erin began restating Rodger's claims. Then she synthesized ideas about a human agent acting and stages of growth, seen in the next three rows. Finally, in row 12, Annie joined the thematic sequence to summarize and decontextualize statements stating, "A plant seed needs water, light, and dirt." While this claim dropped information about stages of growth, it was a clear synthesis of the majority of the prior utterances.

I describe the preceding sequence as a thematically focused on processes dependent on human agency. The semantics of the claims were contextualized all in terms of Rodger's initial assertion that when you plant seeds

[15] I brought several plants to class including flowers, vegetables, and house plants. Students made observations of all these plants, so they had a larger array of types of plants to consider.

you need to make the hole big enough. There were two exceptions to the use of human agency in this thematic sequence. Breanne's comment about stages of growth is interesting. I interpret, that she was thinking based on Rodger's claim of 'you planting seeds.' It was as though Breanne was describing the things that one would notice if they could watch a seed germinating. Alternatively, since experiences from the lesson sequence focused on stages of development, it is possible that she was retrospectively describing her experiences planting seeds.

Annie (row 12) also was another exception. She listed all the things plants need, almost like a set of instructions to ensure proper growth. By implying instructions, one interpretation is that she is telling all the things a human agent needs to do to ensure proper growth. Another interpretation of Annie's utterance is that it was about circumstances for growth. If this was the meaning that she intended, then her utterance was outside the on-going thematic sequence. In either case, Annie's utterance was the last in this thematic sequence. Therefore it could also be seen as a signal to shift semantic relationships.

The final set of utterances in this discussion was just alluded to. This stemmed from a question that I asked the class. I asked the students to explain where seeds come from (row 16). Semantically, the question asked students to describe circumstances that account for generation of seeds. Beverly, when answering my question, said, "they grow on trees (row 19)." This could be interpreted as semantically describing processes of seed growth. However, in the context of the situation, it fits the thematic sequence about circumstances.

Thus I interpret her utterance to be saying that the requirements to have seeds are trees that produce those seeds.

Beverly's initial assertion, in row 18, described seeds as coming from trees that grow seeds. Semantically, she related the problem of origins to the producer. Annie (row 20-22), shared Beverly's utterance telling about the way a human agent could get more tree seeds, by planting the seeds, having them grow and produce fruit that contained more seeds. Her elaborations, while not following the exact semantic relationship that Beverly established (this would be an easy way to participate in the on-going thematic pattern), did maintain topical coherence by talking only about trees and trees seeds. In order to elaborate on Beverly's point, Annie relied on semantic relationships of human agents and processes.

The main findings of this focal discussion are similar to the findings of the preceding focal discussion. Students shared utterances focused on describing processes that depend on human agency. Students focused on making statements about how to control phenomena in the world. While, students did directly evaluate one another's claims, their strategy involved shifting the semantic relationship of the original claim. Finally, the complexity in this discussion as compared with the Wind and Kites discussion suggests that the differences in teacher action, content, or students' roles in the discussion impacted the thematic sequences of the account.

Semantic Relationships and Thematic Sequences in other selected discussions

Looking across the selected discussions students semantic relationships led to four main types of thematic sequences. These thematic sequences expressed relationships that made claims about characteristics, circumstances, processes, and human agency. The findings presented to this point suggest that human agency was a dominant type of thematic sequences in the discussions. However, looking across the discussions this is not quite the case. Process based thematic sequences were prominent in three of the five remaining selections. The other two talks focused on characteristics and circumstances.

However, there is an important distinction to make between the focal discussions and the remaining talks. A reason discussions were selected had to do with multiple students using shared utterances. Two of the five discussions (January 1, 2002 and January 9, 2002) were dominated by a single speaker, thus while there was limited use of shared utterances in the discussions these did not lead to joint construction by the group. Similarly, the May 15, 2001 discussion about wind vanes involved my scaffolding observations of phenomena. As a result there was limited joint construction in this discussion because of my scaffolding. One statement of human agency was included in this selection, but it did not develop as a thematic sequence.

The May 5, 2001 discussion about clouds focused on processes and there was joint construction in this discussion. The joint construction was launched by a sequence that followed a human agency thematic sequence that later shifted to be only processes. The May 13, 2002 discussion about seeds in a flower

included considerable of student talk that focused on processes. This is an interesting case because the selection picks up at the end of seeds focal discussion described here. However, while there was student talk, it focused on responses to one student raising questions about the claims other students made. Thus the joint construction, if it could be called that, was not thematically related as much as it was related in participation. As a result students' utterances did not build on one another. Rather, they took up the initial question, posing theories in response.

Content: What is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

Findings in this section focus on the nature of students' jointly constructed accounts in the selected discussions. First, I will describe the accounts resulting from students' joint construction, in terms of experiences, patterns and explanations. This is done to show how students are ultimately engaged in scientific practices that focused on practical reasoning about how to exert control over phenomena in the world. This will illustrate the nature and accuracy of the accounts that students jointly construct.

Students' accounts as practical reasoning about how control phenomena in the world.

While many of the things implied in this section have already been stated in previous presentations of data, I would like to first make explicit what I am meaning by practical reasoning using one example from the focal discussions.

Then, I will present descriptions of all the selected discussions to give a sense of the accounts generated in each discussion.

Practical Reasoning in one instance

One aspect of the theoretical framework involved explanation of patterns in experiences with phenomena. Explaining is a cognitive task of making sense of the set reported (or known) experiences with phenomena, identifying a pattern in those experiences, and providing a reason that the pattern makes sense and/or predicts future experiences. Explanations were not common in the selected discussions. When explanations did occur, they were often independent of patterns or observations already described in the discussion. When patterns and experiences were connected to explanations, descriptions of human agency figured prominently in the experiences or patterns leading up to the explanation. Thus students relied on human agency to develop accounts that explain phenomena based on the reported experiences and patterns.

In the wind and kites discussion, Lora and Rodger collaborated on an explanation of the function of the string in kite flying, giving reasons why the string was important to flying kites. Lora connected to the notion that the string allowed a person to keep the kite from blowing away in the wind. She said, "If you want to fly a kite you have to have string. When you have string it [the wind] doesn't make it fly away (lines 44-45; May 15, 2001)." This statement culminated a sequence of claims that began with experiences described by Marquisha telling about actions of a human agent to make a kite fly (lines 22-26; May 15, 2001). Then Lora added a pattern that having a string allowed the user

to control kite movement (lines 39-40; May 15, 2001). Finally Lora added the reason that without the string the kite could fly away (line 45; May 15, 2001).

Lora's reasoning focused on the practical nature of the phenomena, or what a person needs to do in order to achieve the desired outcome. However, Lora's explanation was not one that relied on model-based reasoning,[16] which would explain that the kite will not fly without the string and its particular attachment. Model-based reasoning would conclude that her claim that a kite without a string would "fly away" because of the wind is inaccurate. However, it was probably experientially and/or practically accurate, from her knowledge that objects get blown away in the wind. Furthermore, students had experiences, not surprisingly, loosing kites in trees or when flying high in the sky and the string broke, flying away to not be seen again. In Lora's experiences kites did 'fly away,' making a string important to not loosing kites.

In this discussion context, Lora positioned her claim in terms of a practical explanation that was meaningful and useful to students. However this same explanation did not rely on model-based reasoning to explain the function of the string. In Lora's explanation, even without the string the kite would still fly; the string only keeps it from flying away. However a model-based account would include the way the string keeps the kite at particular angles in the sky. The students were caught in a science learning problem of generating explanations based on limited experiences. Scientific explanations often include extensive patterns unavailable to students. Therefore it is not surprising that students'

[16] This is described in more detail later in this chapter.

explanations often seem incomplete and don't have the parsimonious rigor of model-based explanations.

Descriptions of selected discussions

The above example of reasoning was similar throughout the selected discussions. To see this, the following descriptions survey the accounts students constructed to see the kinds of reasoning that students engaged in. The following summaries present the jointly constructed student accounts, including: 1) syntheses of students' knowledge claims, 2) their claims about experiences, patterns and explanations, and 3) the connections between their claims. In addition, each account includes all student inclusions of human agency, as well as questions that prompted discussions. The account summaries are in chronological order, including specific speakers only as relevant. The focal discussions are discussion three and six in this set.

1) Clouds as semi-solid absorbent objects – from May 5, 2001

Students described clouds as semi-solid or solid objects in the sky that absorb liquid water and then precipitate that water in the form of rain or snow. However students did not relate clouds to their lived experiences with things like fog. Students attributed precipitation to times when the cloud absorbed too much water, which was attributed to one of two criteria: the quantity of water or the weight of the water.

Students recognized a pattern that water came from clouds and needed to get to the cloud. Students were uncertain how liquid water got to the cloud from the ground, but claimed that water was not just, 'in the air' but rather the cloud

absorbs the liquid water. One student claimed that the water came from Jesus. Students developed analogies for mechanisms to transport the water from the ground to the cloud that compared this action to their personal experiences using sponges, bowls, and cotton. In addition one analogy seemed to rest on virtual experiences (seeing things on movies or television) comparing clouds to spaceships, with a 'laser beam that sucks up'.

One student attempted to correlate temperature and rainfall. Picking up on this, Mrs. Corbin asked the students whether it needed to be warm or cold to form clouds. The students had theories that the temperature was and was not relevant to clouds. However, there was no consensus about relationships between temperature and clouds. One student included an explanation from her mother that hot and cold air come together to make clouds.

2) Wind vanes indicate wind directions – from May 15, 2001

Based on an experience in the discussion, the students' claims indicate that they correlated the direction they felt air move from a fan and the direction wind vanes pointed. One student made an uncontested claim that the wind vane direction was a result of air movement exerting forces on the wind vanes. However, another student was also uncontested in asserting that my wind vane operated differently because I made it differently. Students did not attempt to offer explanations in this discussion.

3) Flying kites requires wind, string, and a pilot – from May 15, 2001

Building on the preceding discussion about wind and wind vanes, I asked students to explain how kites work. Based on school based experiences with

kites, students focused on describing what a human agent, 'you' does to make kites fly. Several commented about the string, wind and the structure of the kite being important. Each successive student utterance moved away from inclusion of a human agent to increasingly de-contextualized statements about the wind, the string and the kite.

Connecting wind direction and kites flying, I drew a sketch on the board including the human actor and a kite and asked students to describe the wind direction. Students consistently used, "this" and "that" way to describe the wind direction. However, they did not agree which direction the wind would be blowing in my drawing. I concluded the discussion suggesting that we needed to test the different ideas.

4) Light shoots and spreads – from January 7, 2002

This selection was initiated based on my question, asking how "light gets from that light bulb to my eyes?" Breanne almost solely developed this account, posing the theory that light "shoots" and "spreads" from the wire inside the light bulb. I asked her to explain what she meant by spreads. She explained spreads using a lamp in the classroom as a specific example, describing how the light from the lamp spreads to illuminate a specific area.

One student made an analogy to spreading like one might do in gym class by spreading your arms to the sides to assure sufficient spacing (probably based on personal experience in gym). Breanne then added descriptions of the way that light spreads including faster, closer, farther, wavy, uneven, zig-zag, and

curly. She continued adding the presence of a generic human agent turning on and off a lamp, describing light from a turned off lamp as "still".

A second student asked how a light bulb could spread. This introduced the problem of polysemous word meanings. Breanne attempted to answer this using a human actor turning on a hypothetical lamp that will not light a whole room. The selection ended with me attempting to develop an analogy for Breanne's explanation.

5) Light reflecting in a prism makes rainbows – from January 9, 2002

Students observed and described observations of two rainbows produced by the prism. They included descriptions of the spectra (rainbows) and of the light that was not refracted, but visible. These descriptions took place during observation and afterward when many students were attempting to explain how the rainbows were produced.

During these observations one student speculated that a particular part of the prism made the rainbow. Another speculated that the reason there were two rainbows on the ceiling was that there were two sides facing up. Once the classroom lights were turned on, students continued to explain the production of rainbows. The main explanation offered was that light was reflecting in the prism. Reflecting was described, using words and gestures, as being like a line that something reverses against. However this was confusing for some students. So the assertions were complemented with drawings to represent light moving and reflecting in the prism, which clarified the confusion.

Reflecting was compared to a ball bouncing fast. This led to a question from a non-consenting student. Ultimately this challenged the bouncing ball analogy and resulted in rejection of the reflecting explanation by its originator. However, others continued to support this idea and attempted to explain how the analogy could work. The claims led to introduction of human agency and specifically the ways that I held the prism in front of the light source.

6) Seeds are things that grow into plants (with help) – from May 13, 2002

This selection began based on the question, "what is a seed?" Annie defined this as a process, saying a seed is something that grows into a plant. Isaac varied this claim saying, seeds as what a plant starts as. These claims were built on, adding decontextualized descriptions plant lifecycles and things a seed needs to grow. Annie built off her description of seeds growing into trees and Beverly's claim about seeds (described more below) describing a life cycle of a fruit bearing tree. This included a decontextualized description of fruit, seeds, and tree growth.

Rodger and Erin described various degrees of human agency by talking about how a generic 'you' can plant seeds and what 'you' need to do in order for seeds to grow. Brittany challenged Erin's claim that "seeds grow into flowers." Her challenge was that not all seeds grow into flowers. Rodger issued this same challenge to Annie about her statement that seeds grow into flowers. In response Annie added, following the human agency approach, that you could plant a tree seed and get a tree.

I asked students where seeds come from. Isaac said they come from nature. Beverly said that seeds came from trees, which Rodger also challenged this as a general claim. Annie added to the ideas about seeds coming from trees and later said that other seeds come from stores.

7) Seeds in a flower and seeds in the ground – from May 13, 2002

A central claim introduced in this selection was a drawing of a sunflower to assert that seeds are in the center of a sunflower. Breanne challenged this claim through the remainder of the discussion, asking her peers to explain how there could be seeds in a sunflower. Breanne's claim was that the seed was in the ground, growing the plant, and therefore could not be in the flower.

One response to Breanne's question relied on the importance of flowers and seeds in plant propagation. This explanation focused on the life cycle of a flowering plant, but did not treat, as Breanne seemed to, the seed and plant as co-existing entities. However, this same explanation introduced human agency, suggesting that 'you' needed to plant the seed to grow another plant and that the plant needed 'you' to grow. It did not explain how a plant produced a seed.

Another explanation was that bees make the seeds and put them in flowers. This explanation received limited uptake. Rodger challenged this claim, but this was limited to two turns.

A final explanation was that the seed, once roots come out and the plant grows, travels up the stem and breaks apart in the flower to make new seeds. Breanne challenged this asking how a seed can go up a stem.

The nature and accuracy of students' accounts focused on practical scientific reasoning, but not on model-based scientific reasoning.

In this section I consider the nature and accuracy of the accounts that students constructed. This is an attempt to consider students' conceptions of the phenomena discussed in these contexts. Ultimately it is impossible, based only on oral discussions to say anything about what each student understands. However, it is possible to evaluate the accounts in these discussions based on a systematic process.

Such analysis requires considering the surviving claims, those not rejected by the group, and comparing them with a scientific account. I will present analyses of findings from the two focal discussions, and then summarize findings for the remaining accounts. For each account, I present students' claims in the discussion, explaining why or why not I consider them accurate. It is important to recall that these are young students, so their accounts may at times be simplistic. In order to provide a point of comparison, I will compare the students' jointly constructed accounts with accounts developed based on the Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) and other sources[17]. Benchmarks for Science Literacy suggests developmentally appropriate science ideas for student learning of specific topics in specific grades. Therefore, I am using it here as a measure of whether students' accounts were developmentally appropriate.

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[17] Benchmarks for Science Literacy does not specify particular information about the topics included in all the discussions. Therefore it was necessary to use other sources to develop these accounts. I have not cited those sources because I do not draw quotes and relies on general scientific knowledge.

To compare between the student account and the scientific account, I will **bold** the overlapping points and outline points of disagreement between the accounts and *italics* are portions of the accounts where specific claims are not included in the corresponding account. The intent of this analysis is to consider accuracy and appropriateness of accounts that students generated.

Wind and Kites

Beginning with the wind and kites talk, table 4.3 outlines the claims of the account that students jointly constructed. Recall that this discussion focused on kites, attempting to explain how kites fly based on students' experiences flying kites at recess. It also involved applying knowledge from experiences to a drawing to infer the wind direction in the representation. Thus this discussion was structured around experiences, required applications of patterns, and asked students to explain phenomena using experiences and patterns. It is important to note that the context might have not provided chances to make coherence in these elements. Furthermore, the context did not necessarily suggest that their account correspond with science.

Table 4.3 – Evaluation of Accounts in Wind and Kites Talk

	Lines	Student Account	Student Conception	Scientific Conception
1.	1-14	Mr. E.: How do those kites work?	The question implies that the kite does something that causes it to fly.	**Wind pushes on** *the surface of* **the kite.** *The kite surface deflects the wind making it move slowly across the front and quickly across the back of the kite. The angle*
2.		Multiple: Wind	**Kites fly by wind pushing on them.**	

	Lines	Student Account	Student Conception	Scientific Conception
3.		Bobby: the string	**The string** makes the kite fly.	*of the kite, held by the* **string**, *causes air pressure differences that create lift.*
4.	14-32	Marquisha: you make it	Human action creates forces that act on the kite to make it fly.	Kites fly regardless of human agency. Human action designs the shape and surface of the kite and initiates the event. **Wind pushes on the surface of the kite.** *The kite surface deflects the wind making air move slowly across the front and quickly across the back of the kite.*
5.		Marquisha: you hang onto string and run	Running, while holding the string, forces the kite into the air, causing it to rise above the ground.	
6.		Marquisha: The kite flies in air by the wind	**The wind makes the kite fly into the air.**	
7.	39-45	Lora: The string controls the kite; you have something to move in different directions.	**The string allows a user to move the kite from one location in the sky to another.**	**The string keeps the kite** *at an angle in the wind. This helps create different air pressures. This angle keeps the kite* **flying**. *Without the proper angle the kite flies poorly or not at all.* A kite will not fly without the string. *The tension in* **the string allows a user to move the kite from one location in the sky to another.**
8.		Lora: If you want to fly a kite you have to have string. When you have string it doesn't make it fly away.	The string prevents the kite from flying away in the wind. The kite would continue to fly if the string were missing.	
9.	58-62	Rodger: The string control the kite because for the kite to stay up in the air.	**The string keeps the kite flying, making it stay up in the air.**	**The string keeps the kite** *at an angle in the wind;* this *angle keeps the kite* **flying**. *Without the proper angle the kite flies poorly or not at all.* A kite will not fly without the string.

	Lines	Student Account	Student Conception	Scientific Conception
10.		Rodger: they make it out of wood. they just have a little bit of thing.	**Someone builds kites using wood and other materials.**	**Kite designs use many materials**, in various shapes, and sizes. – THIS IS A DESIGN STATEMENT.
11.	78-125	Mr. E.: Which direction does the wind blow?	*The question asks for interpretation of phenomena based on a drawing.*	**The wind blows into the face of the kite.** *Or, the kite should be downwind from the operator.* Air moving from areas of high pressure to areas of low pressure causes wind.
12.		Multiple: 'this' or 'that' way (toward or away from kite)	*Students assert that the* **wind blows towards** and away from the kite.	
13.		Lora: The wind goes anyway it wants.	Wind, unintended, [illegible]	

Looking at the bold words, the students' account included several ideas related to and partially consistent with the scientific account. However many of these ideas only partially account for how kites fly. To describe the partiality of the claims I will need to talk about the student account in connection with the scientific account. Therefore, when referring to a row in the table, all cells in that row will be pertinent.

In row 2 students collectively identified wind as important to kites flying. However, students did not identify the role of wind. It was not until row 6 that students identified their understanding of the effect of wind on the kite. The students' account focused on the wind pushing on the kite, providing no explanation about how wind made the kite fly. Scientifically, this has to do with wind speed and air pressure. Deflected wind on the front of the kite slows the

wind, creating a region of high pressure in front of the kite and a region of low pressure behind the kite. Since air moves from high pressure to low pressure, this creates a force (or lift) on the kite. (NOTE: Kites rely on the angle of the kite relative to the wind, but this is discussed in more detail below.) Students had some problems in their account related to wind. In row 8, Lora thought that wind always pushes kites into the air and potentially pushes the kite away. She later made the claim that wind "moves any direction it wants (row 13)." Finally, in row 12 students were collectively unsure about the wind direction. Some correctly thought the wind blew in the face of the kite. Others thought that the wind blew behind the kite.

According to Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993), students at this level should understand that we can feel wind. However, this discussion really focused on relationships between force and motion. In terms of motion, Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) suggests that these students understand that things move by pushes and pulls. Based on this standard, the students' account of kites flying was appropriate for them.

The students and I ventured into areas that were conceptually beyond the students according to standards and as revealed in their comments. It was in these conceptual adventures that the students ended up with some inaccurate accounts of the phenomenon. For example, the anthropomorphism of wind in row 13 represents one of these inaccuracies. An argument could be that getting

into developmentally inappropriate[18] areas led students to need to make inaccurate claims. This might lead students to inaccurate understandings of the world. Therefore a response would be to limit such discussions to ones that are developmentally appropriate.

However, I argue that these discussions were vital to helping students begin to think about how phenomena and explanations can be related. In this discussion, students were working with relatively complete sets of phenomena and attempting to make sense of those. They identified patterns and offered limited explanations. Therefore, this engaged them in practices important in science, considering sets of experiences from the material world. The problem is that ultimately all phenomena from the world potentially lead to topics that are difficult to explain based on third grade science. It becomes difficult to be developmentally appropriate and engaged in practices of science. In this case, attempting to connect kite flying, an indicator of wind, with a natural phenomenon is real and relevant and thus an application of science knowledge. Furthermore, I think, that is was something the students found meaningful and useful. But at the same time the students and I struggled with because of the complex conceptual adventures of meaningful and useful explanations in real contexts.

Students' comments about the string are interesting. It was clear that students saw the string as important to kite flight. However, students had different ideas about the function of the string. One idea was that the string was important only for the kite flier, see rows 5, 7, and 8. However these claims were

[18] The argument is that Benchmarks is based on empirical research about children's ideas and is therefore a developmentally appropriate set of standards. This argument is debated, but will not be the topic here.

slightly inconsistent about the string. At times students thought that the string allowed a user to control or steer the kite. Other times students seemed to indicate that the string kept the kite from flying away (row 8). The common thread in these ideas was the shared notion that the string enabled a human agent to do something with the kite. This was slightly different than the idea in row 9 that the string makes the kite stay in the air. Students seemed, in the discussion to treat these as compatible (especially from the perspective of Grice (1999)) since they did not challenge one another. It is unclear whether students realized the importance of the string. Scientifically the string determines the angle of attack (angle of the kite relative to the wind). The kite will not fly without the string. However, human agency is required. The kite flier must align the kite and the wind, as well as moderate the string and the angle of attack in order for the kite to fly.

Connecting to Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993), the ideas about the string relate to balanced and unbalanced forces. These ideas help describe the motion of objects, and a this level should be described in terms of pushes and pulls (American Association for the Advancement of Science, 1993). Students were attempting to coherently connect their experiences flying kites and the function of the string. Yet they did not talk about the tug or pull a kite flier feels on the string. The result was a sense of disjuncture between things that students thought the string was important for and the role of the string in causing a kite to fly. Ultimately an account that accurately relates string, angle of the kite, and the wind, in a

coherent and complete fashion would be a challenging even for a science literate adult to construct. Thus the students' account was not problematic. Furthermore, it seems important that they intuitively included the string as relevant and attempted to include this in the account. This supported them in developing a practical of the things done to control the flight of a kite. Many people would not even include the string as important in flying the kite. Therefore in this sense the students' account was *more* scientific because it attempted to account for all relevant aspects of the phenomenon. However, as already suggested, model-based scientific reasoning was not accomplished in this case. As a result there are aspects of the account (such as the role of the string) that seem inaccurate or incomplete.

What are seeds?

In the talk about seeds, represented in table 4.4, students attempted to generate a definition for seeds. Students brought experiences with seeds into the discussion. Furthermore they described patterns of plant life cycles. However, their discussion focused heavily on human actions in planting and caring for seeds and plants. Again **bold** sections are overlapping points, outlines are points of disagreement between the accounts, and *italics* portions of the accounts where specific claims are not included in the corresponding account.

Table 4.4 – Evaluation of Accounts in What are Seeds Talk

	Lines	Student Account	Student Conception	Scientific Conception
1.	1-28	Mr. E.: What is a seed?	*The question requests a definition of seeds.*	*Seeds are dormant embryonic plants. Many* **plants grow from seeds**. *Some plants do*

	Lines	Student Account	Student Conception	Scientific Conception
2.		Annie: It grows into a plant	**Seeds grow into plants.**	*not produce seeds in order to reproduce.*
3.		Isaac: A seed is something that before it's a plant, like a flower or a tree, it starts as a seed.	**Plants start as seeds.** *Plants are flowers and trees.*	
4.	100-143	Rodger: You have to dig a big hole to plant big seeds.	**Seeds require the appropriate space to grow.**	*Seed germination begins plant growth. The seed requires things to grow:* **planting depth, space, and moisture**. *A seed grow roots, then stems and finally leaves after germination. The seed uses food stored in the cotyledon as energy and matter for growth. Seeds do not need sunlight to grow. Soil transports* **water** *to the seed, from rainfall or* **human irrigation**. *Soil (in germination) is a medium for root development and water transport to the seed. However, seeds will germinate without soil.*
5.		Rodger: First the seed has leaves and the green little plant comes from the seed but it also comes from the stem.	Leaves, the plant and the stem grow from the seed in that order.	
6.		Erin: You plant the seed and give it water and it grows into a plant and then into a flower.	**Seeds need water to grow. Human agents provide seeds water in order to grow.**	
7.		Annie: A seed needs water, light, and dirt.	**Seeds need water,** sunlight and soil to grow.	
8.	144-150	Brittany: Not all seeds grow flowers.	Seeds can grow plants that do not produce flowers.	All sexually reproducing plants have flowers that produce seeds. Not all resemble commonly labeled flowers. *Some plants do reproduce sexually and do not require flowering parts.*
9.		Erin: I know, flowers, plants and other stuff.		
10.	150-195	Mr. E. : Where are seeds from?	*The question asks students to identify seed origins.*	*Sexually reproducing plants produce seeds in flowers. Pollen from the stamen fertilizes the eggs in the ovaries. Ovaries*
11.		Isaac: Nature		

	Lines	Student Account	Student Conception	Scientific Conception
12.		Beverly: They grow on trees and sometimes fall on dirt	*Some seeds grow on trees and fall to the ground.*	*are located at the bottom of the pistil.* **The ovaries swell, producing fruits and the fruits contain fertilized seeds.** *Common things like seed pods, maple leaf fliers, acorns, and most fruits and vegetables are fruits (ripened, swollen ovaries) of flowers.*
13.		Annie: If you got a tree seed and you want to grow it and that tree grows seeds.	*Seeds from trees grow into trees that grow more seeds.*	
14.		Annie: Sometimes those little seeds grow into food. The food drops and the seeds come out.	**The seeds on trees grow in food (e.g. fruit) the fruit drops and seeds come out.**	
15.	200 – 230	Rodger: (to Annie) How would all seeds grow into a flower?	Seeds can grow plants that do not have flowers.	Seeds come from flowering plants. **Seeds grow into the same type of plant that produced them.** Not all seeds grow into plants that have parts commonly known as flowers. For example, **trees produce seeds, but are not often recognized as having flowers. However, not all flowering plants are trees.**
16.		Annie: A tree seed grows into a tree. Then it falls and grows another tree like a life cycle.	**Trees produce seeds that grow into trees.**	
17.		Mr. E.: Rodger was asking if all seeds grow into trees.	**Do all seeds grow into trees?**	
18.		Annie: Some seeds grow into trees.	**Some seeds are tree seeds.**	
19.	231 – 237	Mr. E.: But where do seeds come from?	*The question asks students to identify seed origins.*	*SEE ABOVE: Key point seeds come from plants.*
20.		Annie: Stores	*Seeds are sold in stores.*	

Students had limited understandings about plants as revealed in Table 4.4. However, for me as the teacher, the things that they did not seem to understand were disappointing. Similar to the analysis above, this analysis will look at students' ideas in this discussion. National standards will continue to be used as points of comparison in this analysis.

One idea that students seemed clear on was that plants grow from seeds and that the seed determines the type of plant that grows (rows 2, 3, 8, 12, 13, 14, 15, and 18). This was at times confusing for students because they referred to plants as flowers and trees (row 3). Thus their repertoire of plant types included only plants, flowers, and trees. But the fundamental idea that a seed grows into the same plant as the seed came from was consistent. This was an example of consistency with Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993). According to this source, students should have basic ideas about heredity, which they did in this discussion.

Students revealed some naïve ideas about plants when talking about things a seed needs. They agreed that seeds need water (row 6 and 7), which was attributed to actions of human agents (row 6). However seeds do not rely on human agents exclusively to grow and are adapted to their biome so that such nurturing support is not required to grow. I think a problem that students faced was that many of their experiences with plants involve humans watering them. They likely experienced parents watering lawns, trees, gardens, and house plants. In fact, all the plants that we looked at in the classroom required humans

to water them. Therefore their claims about human agents watering plants was likely coherent with the majority of their experiences. This raises another point to consider, the completeness of the experiences students were considering. Certainly they had experiences with plants that were not provided water by people, but these experiences were not explicitly introduced in the context and thus not part of the account students constructed.

Students also thought that seeds need soil and sunlight to grow (row 7). This is a particularly interesting point because seeds do not need sunlight. Food energy is stored in the cotyledon and seeds do no need sunlight to produce food energy. However, the student in this utterance (row 7) has included a common, accurate understanding that plants need sunlight. Similarly soil does transport water to the seed, but again is not required to germinate the seed or grow. However, these points are ones well beyond students abilities.

In this respect, students had aspects of a developmentally appropriate scientific account. Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) suggests that students should know that living things need air, water, and food to survive. Students indicated that they knew that seeds and plants need water to survive. However, students thought that humans provided water to plants, according to their claims (row 6). They did not include natural sources of water such as rain or groundwater as sources of water for plants. Furthermore, students did not mention air or food when talking about plant needs. Thus they have partial understandings of the ideas included

in that Benchmark, but these ideas were incomplete and in some ways inaccurate.

Finally, an interesting point that arose in the discussion was students' considerations of flowering and non-flowering plants. Row 8 highlights that students agreed that some plants do not have flowers. This is true; however, the problem is that seeds usually come from fruits which come from flowers. Thus seeds usually come from flowering plants. Students did understand the connection between fruits and seeds (row 14). But they struggled with the remainder of this idea because of their limited understanding of seed production. Furthermore, the account that they constructed left out seed production in plants. But it attempted to include plant lifecycles (row 16). Since students did not have understandings of seed production, their account was limited.

Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) does not include understandings of seed production until middle school, so these were not appropriate ideas. However, in this case the challenge of relevancy versus appropriateness arose. Students should know about heredity at this age. They should understand that a dandelion does not grow into an apple tree, which was the fundamental challenge in this case. However, the problem is that a complete and accurate account for this would involve long term experiences planting multiple sorts of seeds (which is not feasible) *or* explanations of seeds coming from flowers and sexual reproduction in plants (which is not appropriate). I am not convinced that experiences planting seeds would be sufficient in this regard for students to

develop a scientific account. My hypothesis is that students would focus their explanations on their actions planting and caring for seeds.

But in terms of this and the particular context, what was the quality of students' accounts? Students strove in this discussion to develop a coherent account. They defined seeds as something that plants grow into. This led them to needing to describe the things a plant needs to grow. From this, students returned to a fundamental pattern of life cycles. Since many of the experiences students introduced explicitly involved actions of humans controlling phenomena, the experiences, patterns, and explanations that students were explicitly considering, still fit their account, but would not fit a model-based account. Other experiences, patterns, and explanations might have been helpful in developing a more complete account. Some of these were appropriate for students while others were not. Finally, explanations in their account might have not been appropriate. As a result this account had qualities that made it important to students participating in sense-making in science, but did not facilitate their development of an accurate model-based scientific account.

Accounts for other selected discussions

For the remaining accounts, it is difficult to complete this kind of detailed presentation of analysis and still keep this writing to a reasonable length. Therefore I will highlight some important points in the other discussions, but not in such detail.

The student account of clouds did not include an explanation of processes of how water gets into the clouds. This was a problem the students worked on

and attempted to develop analogies to explain. However, since the students were not familiar with and had not explicitly been taught about evaporation or condensation and the relationship of this principle to clouds[19], this challenge was not surprising. This led the students into conceptual difficulties which they attempted to resolve by creating or developing a mechanism to transport water from the ground to clouds that described clouds as solid objects. The account is interesting though because students engaged in an activity of attempting to account for the experiences they had and provide a coherent and complete account of phenomena related to clouds. Though the account struggled in terms of accuracy, it was remarkable in terms of being coherent around different phenomena and complete in attempting to introduce relevant phenomena.

The discussion about wind and wind vanes is interesting to consider for a couple of reasons. The account provided by students was developmentally appropriate. The causal explanation that the wind pushed the arrows was appropriate, but to be scientific would need to offer some explanation about unbalanced forces. However, the second point is somewhat more interesting. The challenge that I constructed my wind vane better was actually interesting. This presented an issue of technique and accuracy that is often considered a hallmark of scientific activity. By challenging the technique the student was raising an issue of the coherence of the experiences being discussed with the patterns of observation that the account attempted to explain. So while the

[19] Not teaching these concepts is consistent with the suggestions in Benchmarks for Science literacy.

explanation might have lacked depth, the point that the student suggests that students were engaged in scientific thinking.

Both discussions on light failed to include a fundamental concept that students had experiences with in school; that light travels in straight lines. In the discussion, 'light spreads' there was a hint that this was the students thinking, especially Breanne, but it did not become clear. Furthermore, the student who joined Breanne treated light as if it emanates only in two dimensions. In the discussion about prisms, the notion of reflection was actually important to explaining their observations. However it did not explain how light shining through prisms created spectra. In addition, students treated light as matter in this discussion, which was also inaccurate. There was a point in the discussion, a student question revealed the weakness of the ball analogy. Similar to the wind vane challenge, this challenge engaged students in scientific thinking in a meaningful way.

The one remaining discussion about plants involved students' discussion of how seeds could be in flowers. This discussion arose based on a student claim and then a peer question about that claim. This was interesting because at most levels the student account was inaccurate according to science. Yet, fundamentally, students attempted to work with a model or theory about the location of seeds in a flower. Students struggled because they had incomplete explanations of phenomena and as a result ended up posing inaccurate explanations in order to satisfy an unstated quality of coherence in their account.

In summary for the most part students discussions lacked demonstration of complete and accurate scientific understanding. In many cases the larger problem was that my framing of discussions as the teacher did not adequately consider the developmental abilities and knowledge of students. An additional observation worth noting is that throughout the selections there were instances when terminology inhibited the discussions in substantial ways. However, the qualities of the discussions reflected that students wanted their accounts to be coherent and make sense, including all the available experiences, patterns, and explanations. Thus students were entering scientific practice through this work.

Chapter Summary

This chapter began by looking at the ways that students relied on shared utterances to enable their participation. Implicit in students shared utterances were semantic relationships and thematic sequences that revealed things about the nature of the accounts that students found meaningful and useful. Looking at patterns in the thematic sequences and descriptions of the accounts students constructed suggested that students often relied on practical reasoning when jointly constructing accounts of phenomena.

The focal discussions shared common patterns in students' joint construction that relied on human agency as sense-making strategy used to develop claims and accounts. This is summarized in Table 4.5 including generalizations about the nature of the thematic sequences that I tried to get students to use as compared with the nature of the thematic sequences that students used in the focal discussions. The table collapses both focal

discussions, not distinguishing between them. In the table, I include things that did not happen, but desired to happen; these things are included in outlined font.

Table 4.5 – Thematic Patterns in Joint Construction

Nature of Claim	Teacher Thematic Sequences	Student Thematic Sequences
Experiences	Statements that report observations of phenomena, described devoid of human agency.	Statements that report actions of human actors exerting control over phenomena.
Patterns	Descriptions that use laws or generalizations to relate observations in systems.	Descriptions of actions that have predictable outcomes, assuming the agents follow necessary procedures. Descriptions of processes or actions that do not necessarily involve human agency.
Explanations	Statements of models or theories that account for how or why observed phenomena occur.	Statements that offer reasons why certain actions led to certain outcomes.

The important thing to note in this table is that students most often successfully constructed jointly claims when the thematic sequence relied on utterances of human agency. I desired and at times succeeded in moving students toward thematic sequences that relied on somewhat model-based reasoning. However, I was only successful in doing this for certain phenomenological patterns.

Other selected discussions included instances when the students began to move toward model-based reasoning in their accounts (See 'seeds in a flower' and 'clouds' talks in Appendix A). However, these instances of model-based reasoning were preceded by thematic sequences using practical reasoning.

In the next chapter I will offer explanations for these findings. This suggests implications for teaching and learning science as well as directions for future research.

Chapter 5

Accounts and activity in discussion contexts

Introduction

An early science teaching memory comes from after I had been teaching about four weeks in a different third grade classroom. At the beginning of a lesson, a student raised his hand and asked, "When are we going to start learning science?" His question initially confused me because I thought we had been learning science for the last four weeks. After asking some questions, I learned that he, along with many of his peers, thought learning science involved reading in books and learning definitions for scientific principles. For the next lesson, I obliged the students by using books, leading a lesson that involved reading and finding definitions. When they read the words that they had been using so fluently, they realized that we were learning science, but not doing it the way they assumed learning science occurs. The point of this story is that students and teachers have ideas about learning science in school, what constitutes science, and appropriate ways to engage with science ideas. Therefore it is safe to assume that they might also have different ideas about what will constitute meaningful and useful explanations of phenomena.

This study showed that a group of students and a teacher engaged in whole group discussions had different, but sensible ideas about the kinds of accounts and explanations that were meaningful and useful in science. Furthermore, when students constructed accounts around statements of human

actions including actions of an indefinite "you" exerting control over phenomena in the world, there was greater student involvement and joint construction. However, when I attempted to shift the nature of students' account to involve claims about the material world free of human control, fewer students participated and in many cases the discussion became triadic (Lemke, 1990). This chapter explains this outcome by suggesting that the students and I had different ideas about the nature of useful and meaningful explanations of phenomena. This chapter also explores implications of this for science teaching in lower elementary grades and makes suggestions for future research.

This chapter revisits the theoretical framework developed in chapter two. This framework was developed to investigate, and in this chapter, to explain patterns of phenomena occurring in video-taped discussions. Chapter three described how I used this model to reveal patterns in the data. These patterns, reported in Chapter Four will be reviewed, highlighting the patterns in the data and evidence I presented. The main thrust of this chapter concerns two issues. For the patterns in the data, I will expand on and develop the explanation about why they arose and also why they make sense. These explanations suggest implications for research and teaching and offer directions for future research.

Theoretical Framework

The descriptive and analytic framework described in this study evolved through repeated examinations of data (Glaser & Strauss, 1967) to allow insight into patterns in the data. With utterances as the central units of analysis, this study attempted to consider students' utterances which I call shared utterances,

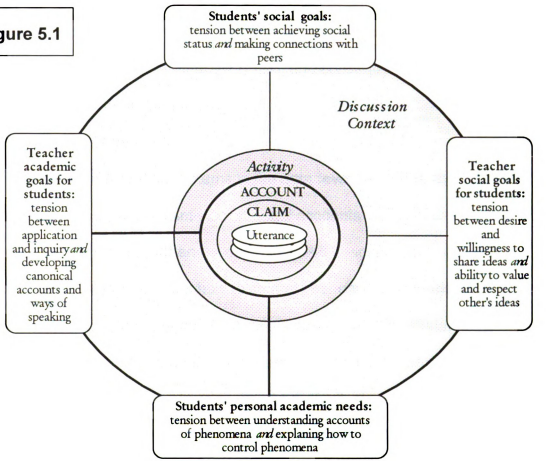
by teachers *and students*, as actions in discussion contexts that become parts of jointly constructed accounts. Looking at the semantic relationship in the utterances and the thematic patterns between utterances helped reveal how utterances became claims as parts of accounts in an activity in a discussion context. The discussion context, similar to Edelsky's notion of the floor that considers the psychological time and space that participants share, involves both social and intellectual dimensions. Social dimensions consider how students relate to one another in the group. Intellectual dimensions reflect the nature of the sense-making that goes on in the group. My assumption and focus in this study is that joint construction can take place based on actions in either or both of these dimensions.

Chapter two presented the framework[20], shown again here in figure 5.1, that treated utterances and shared utterances as actions in a discussion context that were part of an activity. Utterances and shared utterances become actions that can individually or combined with other utterances become a claim. Claims combine to form accounts, which can any of various sense-making strategies[21]. Accounts are constructed in discussion contexts as a result of the activity of the discussion. The point is that while accounts are being constructed, there is simultaneous activity related to students' and teachers' social agendas. Thus discussion contexts are nested or concentric contexts in which multiple goals and agendas are being enacted by both teachers and students. These goals and

[20] This framework was built on both theoretical and analytic dimensions. These are not developed in this chapter. The theoretical dimensions are developed in Chapter Two and the analytic dimensions are developed in Chapter Three.
[21] However for joint construction to occur across utterances, it is most likely that the participants will share sense-making strategies.

agendas serve to advance joint construction of accounts or to participate in activities that support social, and potentially other, goals and agendas.

Figure 5.1



The model is analytic and explanatory, I argue, which is supported by the patterns in the data, showing that not only are sense-making strategies for accounts and social agendas mutually existent, they are also contextually connected. By this I mean that both the account plane and the activity plane can support or constrain one another. Thus activities can heavily focus on the social agendas in the context and as a result constrain the development of accounts. A potential outcome is that activity focused on participation of members may fail

to develop a satisfying account[22]. Conversely a discussion context that is concerned exclusively with an account can constrain the activity to limit social goals and as a result limit participation of all students. A potential outcome of this is that a limited number of participants develop an account that is meaningful and useful to them. However, this account may fail to include the various ideas and perspectives of all members of the group, and consequently it will not be meaningful and useful to those members.

Revisiting the findings

Chapter four described patterns in the data revealing the nature of the utterances and the nature of jointly constructed accounts[23]. There were two main patterns. The first was that when accounts involved describing patterns in the students' experiences in learning how to control phenomena, students effectively used and built on the prior comments of their peers. However, students did not feel that it was important or useful to describe specific experiences or observations related to those phenomena. As a result, students' accounts often sounded more like procedures to accomplish a desired result. The second pattern was that when I attempted to scaffold students' development of accounts to avoid human agency or abstract characteristics of phenomena occurring in the world, the result was that students' joint construction deteriorated and primarily became triadic dialogues between me and one or two students. Before offering

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[22] The question of what constitutes a satisfying account is important. This was addressed in chapter 2, but the key notion that I rely on is that it is relevant and meaningful. These two characteristics are criteria that draw from an individual's sense making strategies.

[23] The model also attempts to account for events in discussions that are not necessarily part of a jointly constructed account. However this analysis has focused primarily on the sense-making activity, or the development of an account.

explanations of these patterns, I would like to review the important features in more detail. Following this I will discuss these results, which will lead to certain implications for teaching and future research.

This study focused on a set of discussions in which I could clearly identify that students talked about one another's ideas. Barnes and Todd (1995) and Gallas (1995) describe ways that students elaborate and expand on one another's ideas to jointly construct accounts. This study built on those findings to identify the pattern that students were more likely to construct jointly accounts when the accounts described how to do things. Looking at the thematic patterns (Lemke, 1990) students used in their utterances provides a triangulated perspective on this pattern. The students were capable of thematically connecting utterances with their peers, but they were more successful when the account being constructed focused on describing patterns in their experiences of successful control over phenomena, or other humans exerting control over the world. Thus joint construction of accounts seemed to rely on statements in which students described the actions of a human actor on phenomena in the material world.

Another pattern revealed in the data related to my attempts as the teacher to help students learn to talk about phenomena without the presence of human actors exerting control over phenomena. This is ultimately a goal of science education, that students could construct accurate and decontextualized statements of phenomena in the world that offer general explanations that do not rely on human control. Science is fundamentally a study that seeks to describe

things in the world free of the actions and agency of humans (Latour & Woolgar, 1986; Traweek, 1988). Yet in this data, students seemed to be less interested in abstracting characteristics of phenomena . Furthermore, as I attempted to scaffold students in making such statements, their efforts to jointly construct accounts decreased. In these instances, the discussions became dialogues between one or two students and me.

Discussion of the results

Given the results, described briefly above and in detail in Chapter Four, why do students seem more successful jointly constructing accounts that involve control over phenomena in the world? Similarly, why does it happen that, when I attempted to scaffold students' use of more scientific sense-making, students' joint construction decreased? This section attempts to offer an explanation of those phenomena by suggesting and exploring the different ways that students, science teachers, and scientists engage with phenomena in the world. I begin with a description of my goals, purposes, and desires for student participation. This allows an explanation of the nature of engagement with phenomena in the world that I attempted to inculcate into students. I will compare this with the things that I interpret that students wanted in the discussions. This inference helps me explain how students described different patterns in their experiences and pursued different accounts of phenomena. As a result, students' shared modes of engagement allowed them to jointly construct accounts that were meaningful and useful to them, but that I found lacking based on my goals for them. Finally, I will offer some explanations about why the students' account

construction and my goals for the kinds of accounts that students constructed did not match well.

What did I want for students and why did I want this?

As the teacher there were things I felt it was important for students to learn. I felt it was important that students learned to jointly construct accounts of phenomena. Whether you think about students in school or scientists in the professional world, the construction of science knowledge relies on combining personal experiences and observations with the observations of others to develop larger data sets that allow increasingly abstracted and generalized claims about phenomena. Thus, students need to learn how to engage discussions that will help them learn to communicate about the data they collected, interpret patterns in their own and others' data, and develop explanations of those patterns that could be seen as independent of their actions in the phenomena. In summary, I wanted students to be able to participate in sense-making discussions that reflected the norms, values and rhetoric of science. Thus I had two important things I wanted for students; they needed to learn to jointly construct accounts and these accounts should reflect the norms, values, and rhetoric of science.

I wanted students to learn to talk to one another and use one another's ideas to develop accounts of phenomena in the world. To accomplish this goal, I provided many chances for students to discuss their ideas and learn to build on the comments of their peers. I modeled this activity for them by revoicing (O'Conner & Micheals, 1996) and repeating (Cazden, 1988) the utterances of

students in the group to show students that this was an appropriate strategy for engagement in discussions. Furthermore, I attempted to shift the sociodynamics of discussions by taking a more participatory role than is normally taken by a teacher. I feel that these were goals that were met by students as they began jointly constructing accounts as seen in the data set. Furthermore, this seemed to develop over time as there were increased instances of joint construction toward the end of the data collection. I would argue that this is an expected outcome of socialization into practices of discussion and joint construction of accounts.

Fundamentally an important aspect of learning science considers the experiences we have with phenomena and learning to make sense of our experiences. I have described one model of scientific sense making that relies on model-based reasoning which connects experiences, patterns in those experiences, and ultimately explanations of why those patterns occur. In terms of experiences, educators commonly think of hands-on learning as important to science learning. From the perspective of model-based reasoning, an assumed benefit of the hands-on learning is that students will individually, or with the help of teachers, interpret from their experiences patterns and ultimately develop or seek explanations of those patterns. The problem is that the model-based reasoning can get lost in the activity. As a result, many educators prefer working towards, 'minds-on' perspectives, which maintain focus on the reasoning activity of learning. In the discussions that this study examined, the goal of the

discussion was to jointly engage the group students in a collective 'minds-on' activity that would help them learn to use model-based reasoning.

Ultimately the goal of students learning model-based reasoning was not fulfilled in this study. The notion that students could jointly construct model-based accounts based on their explanations of patterns in their experiences simply did not occur. However, this study has shown that statements of human agency were important joint construction of accounts by students. Students' joint construction did involve sense-making related to their experiences with phenomena in the world. Thus I would argue that students were involved in fundamentally scientific 'minds-on' activity, and yet not the kind of activity that supported learning model-based reasoning. Therefore, assuming the goal that students will learn to use model-based reasoning as part of their scientific sense-making, it becomes important to think about the ways that students engage with and use their experiences in discussions. Furthermore, we have to think about the role and context of hands-on experiences in learning science as well as the scaffolding and developmental of students' sense-making in order to lead to 'minds-on' experiences that help students develop model-based reasoning.

What did students want to accomplish when they constructed accounts?

It is impossible to know exactly what the students wanted from their accounts. However, in the data set and particularly in the focal discussions, evidence suggests that the students did want to construct jointly useful and meaningful accounts. One pattern described here and in the preceding chapter showed that students were more interested in jointly constructing accounts that

involved human agency. This section clarifies an explanation that a main reason students were interested in talking about human agency was within their abilities. This is a product of their developmental ability and is a normal, predictable sense-making strategy for young children. Another explanation is that students' linguistic abilities can impact attempts to joint construction of an account.

It is not surprising to recognize, as shown in the analytic model of this study, that whole group sense-making discussions are complex contexts that require participants to have multiple abilities to act in a context. Such abilities include, among other things, knowing and using appropriate vocabulary, relying on a network of connected conceptual ideas and models, and being able to describe experiences with relevant phenomena. Young students have limited sets of abilities, which constrain their entrance into discussion contexts. As a result, limited abilities there are impacts on students' potential joint construction. The consequence is that while students might want to participate, their participation can be constrained.

An aspect of students' utterances that became interesting in this analysis was the role that human agency played in students' use of one another's utterances. In both focal discussions, utterances that included human agency became central in the students' joint construction. In the May 15, 2001 discussion of Wind and Kites, Marquisha initially introduced human agency to describe actions taken to fly a kite. There was significant joint construction around Marquisha's introduction of human agency. Similarly in the May 13, 2002 discussion of Seeds, Rodger introduced human agency to talk about planting

seeds. This initiated a thematic sequence about all the things a human agent might need to do when planting and growing seeds. The interesting thing about human agency is that it seemed to provide a focus of accounts that relied on the resources that students had to jointly construct.

Students' use of human agency as a thematic pattern also impacted discussion contexts. I think that thematic patterns of human agency served to balance students' social goals and purposes with their academic needs. I am suggesting that human agency helped manage a tension for students, some of which had to do with language. Constructing semantically clear statements about the world is not easy, especially if the criterion is that these statements be abstracted from human action. This was confounded by the fact that we attempt to have students talk about experiences. As a result they naturally talk about their actions in their experiences. They are familiar and comfortable, possessing appropriate linguistic ability to describe their experiences from the perspective of acting in the context. Thus they situate themselves as knowing something and being aligned with others (who have similar experiences). Thus human agency facilitates their participation in the context, because it specifically relies on their own lived experiences.

Developing an account of their experiences that leaves themselves out is also intellectually challenging. Students' life experiences may have given them few occasions when this seemed like a worthwhile practice. Therefore, using model-based reasoning did not readily have practical use or useful meaning in students' everyday experiences. In contrast, knowing how to do things, like write,

read, draw, ride a bike or fly a kite did have practical and meaningful uses in their lives. Furthermore, their experiences were directly relevant in accounts that described how to do things. Thus, removing themselves required a sort of distancing from their everyday experiences and taking a relative perspective that is quite intellectually challenging.

Another explanation related to the construction of accounts is that joint construction of accounts can at times challenge students' abilities. An example is Rodger, a student who struggled and wanted to participate, but received infrequent opportunities. He struggled because he stuttered and was self conscious about his speech. However he made frequent attempts to join discussions. In the May 13, 2002 discussion about seeds, Rodger attempted to follow a strategy modeled by another student to evaluate a claim. He questioned Annie about her claim that all seeds could grow into flowers. The problem was that Annie never said seeds grow into flowers. In fact she made a general claim that seeds grow into plants in the beginning of the discussion. She refuted his challenge saying that she never said that. In response Rodger dropped his challenge.

Rodger's question attempted to follow a previously successful interaction pattern. Rodger's linguistic ability was limited and thus potentially impacted his actions in the discussion. In the case described above, I think Rodger was limited in his resources in that discussion context and thus the strategy failed to gain him a participatory role in this discussion. He was listening and acting within the context, but the context required him to manage too many things. Rodger

was attempting to manage his social position and status in the class, along with the content of the discussion, the nature of the discussion context and the joint construction of an account. As a result Rodger had many things to figure out in the context and limited abilities to support entry into the discussion context.

Why the two desires conflict …

While there was never outright conflict between the students and me, as the teacher, there were embedded conflicts over what constituted a meaningful and useful account. I encouraged and attempted to support students in jointly developing accounts that connected their classroom experiences with patterns and explanations of those experiences that did not directly involve students actions in those classroom experiences. However, in joint construction of accounts, students infrequently attempted to interpret or explain classroom experiences. In addition, it is interesting to notice that students did generalize about experiences; but this was done in order to describe effective means of control over phenomena, rather than explaining causes for those phenomena. As a result, my interpretation is that our desires for meaningful and useful accounts were conflicting. This section considers the differences between the students' jointly constructed accounts and my desires for the accounts students might construct.

It is interesting that the two focal discussions, selected for the number of student uptakes, actually did not include experiences and did not even draw out of particular experiences. They were general discussions in which students had opportunities to propose and pursue explanations of phenomena. However,

students did have experiences related to each discussion. Before the May 15, 2001 Wind and Kites discussion students had played with kites, built wind vanes, observed how wind vane arrow direction correlated with the direction that bubbles blew in the wind, and had read informational text about wind. Before the May 13, 2002 discussion about seeds, students had dissected seeds, germinated seeds in Ziploc bags, dissected plants, and read in books about plants. Thus in each focal discussion students had multiple experiences with the topics, and yet, only one utterance in three hundred sixty-two combined lines of transcript referred specifically to students' 'hands-on' experiences. In other discussions there were specific references to school based experiences, but these discussions did not lead to as much joint construction or collective validation as compared with the focal discussions. Therefore, one possible explanation is that experiences are not important. However, I think that is not the case, the issue is how students talked about experiences.

I am referring to times in discussions when students used an indefinite you to create hypothetical experiences with phenomena. Those instances, like Marquisha telling how 'you fly a kite' and Rodger telling how 'you plant a seed' were vivid moments in which students gathered around the discussion, jointly constructing claims and an account that many students could imagine or had previously experienced. I think students' prior experiences were potentially based on real experiences, but described in imaginative ways in discussions to establish thematic patterns. It allowed speakers and listeners to connect with

actions in a narrated context. This led to joint construction of accounts that sound like procedures for how to do different things.

In contrast I tried to get students to make statements that described phenomena free of the actions of human actors. In the flying kites example, I asked Marquisha to explain, 'how a kite flies.' I asked her to shift her focus from human actions at the center of her claims, to making phenomena central. Fundamentally we disagreed about what was meaningful and useful to communicate to others when constructing accounts. For students knowing how to do things was important, in fact it was the basis of their successes in school. They demonstrated their abilities of how to do in reading, writing, and mathematics. These abilities were meaningful to students because they were rewarded for successful performance. Similarly they were useful in reading books and writing to communicate ideas. Thus asserting control and telling how to do things was very important in their lived school experiences. In contrast, my scientific expectations were not meaningful or useful to students. Being able to explain the causes and effects that made kites fly was not nearly as useful as knowing how to make the kite fly.

Implications and future research

There are a number of important implications these findings and explanations raise to consider. In the following section I will consider the more salient of these implications. One implication considers the value that science and science learning places on being able to make general statements about phenomena in the world using model-based reasoning. This questions the value

and importance of students' joint construction around claims about human agency. A further implication that is important to consider is the role of hands-on learning in science, especially in the lower grades. This study suggests that there are special considerations to take into account in regards to the kinds of accounts that students construct based on hands-on experiences. Another implication that all science educators often consider is that developmental appropriateness of different topics. Finally, an implication that I have raised involves the issue of students' use of statements of human agency as resources for participation and sense-making in the jointly constructed accounts.

Students learning to make generalized statements in the world

Students' accounts involving actions of an indefinite human agent introduce a number of dilemmas for science teachers. In this study, students' experiences, patterns, and explanations relied on the actions of a generic human, and potentially in the mind of the listener, themselves, acting on things to create the phenomenon in the world. Furthermore, students' accounts were contextualized in a specific experience in which the human agent and the phenomenon were inextricable from one another. The result was that students were not learning to make decontextualized statements about the world. Thus from the perspective of the teacher, students are not learning to generate scientific accounts. However, a teacher would also recognize that students were developing other scientific abilities through their discussions. This involved the ability to construct jointly accounts that were coherent and complete. All the phenomena of concern in the data set can be considered in terms of what

humans are doing in that context. Thus students were learning to manage those human actions and respond to them in their accounts. Furthermore, the indefinite human agent suggests some generality and thus students' intent may have been to generate generic accounts using indefinite actors.

The prominence of students' use of human agency as a thematic pattern in discussions also suggests things to think about in terms of learning science. In the focal discussions human agency played an important role in joint construction of accounts. The introduction of human agency supported students' development of hypothetical experiences. These hypothetical experiences created contexts in which students could imagine and participate in discussions in multiple ways. Ultimately, the activity of science involves imagination making. Nobel Physicist Richard Feynman describes the importance of imagination in the following quote:

> The principle of science, the definition, almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific "truth." But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in a sense that gives us hints. But also needed is imagination to create from these hints the great generalizations – to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we have made the right guess. (pg. 2, Feynman, 1994)

One aspect of Feynman's quote suggests that science process and construction of scientific knowledge fundamentally involve the use of imagination. Students' use of human agency suggests that students are imagining things as they discuss and creating contexts in which they can think and act. Human agency claims enabled joint construction across students and across discourse contexts. However, in this particular discussion I want to think about how the introduction of human agency as relying on imagination.

However, in this data set there never was a collection of sets of data (multiple experiences) to reason about. Thus thinking about models in a discussion might have been inappropriate. All the experiences included in the data (the students set of experiences) led to the same investigations, the same questions, and the same results. So there is no reason to generalize because there are no general phenomena ever experienced. Therefore it makes perfect sense for students to include human agency because all the data were collected by them and anomalies are directly attributable to human agency in most cases. However another interpretation of the same situation is that students were using human agency as a way to imply generality. The indefiniteness of 'you' might be a way students were signaling that they were talking about a phenomenon they expected everyone to know about and thus it intended generality. It is difficult to know a speaker's intent. But it does seem important to continue to think about how students were using human agency in discussions to make claims about phenomena.

Students' accounts and hands-on experiences

A dilemma that science teachers face is the challenges of connecting hands-on experiences with discussions in science learning. If students rely on statements about human agency as a thematic pattern and explanatory framework, when students attempt to construct and validate joint accounts of science experiences in school it is likely that they will focus on human actions, or statements of human control in their explanations and accounts. Human agency was important for this group of students making sense of phenomena, which seems a likely problem for many classrooms. If we want students to develop abilities to speak differently, then it might be important to think about how we support students' development of those abilities. However, as a teacher pushes towards such decontextualized scientific accounts using model-based reasoning, there is danger of shifting the discussion context so that students feel the goal is to replicate certain forms of knowledge.

Teachers who engage in discussions in their science teaching will often connect these discussions with students' inquiries and investigations of the world. I am suggesting that this practice is vital and yet also complex. It is vital because it introduces students to the need to develop and make statements about the world that are coherent, complete, and accurate. I feel that students can better achieve this goal through joint construction of accounts that involve experiences, patterns, and explanations. Hands-on experiences provide some of the experiences used in those accounts.

Unfortunately it is not as simple as collecting data and then having a talk, letting students develop theories to explain science phenomena. Students need to learn the practices of negotiating experiences and patterns, which in some ways students were doing in these discussions. Their efforts to make statements of control assumed patterns without stating them explicitly. However, in these data, students were not developing as much ability in knowing how reason based on models or explanations of experiences with phenomena. One possibility is because the patterns that students implied in their accounts of phenomena were rarely made explicit. It is possible that this is a developmental path. Students must first learn the practices and then learn the ways of constructing model-based scientific accounts. But, an important question is whether learning the model of scientific reasoning is best accomplished by connecting it with hands-on experiences. Possibly we need to investigate other options for learning this mode of speaking and acting in the world.

The developmental appropriateness of specific topics in science

A third dilemma is considering the developmental appropriateness of topics. This was an issue that came up, especially in the May 15, 2001 discussion about wind and kites. The problem was that as soon as students begin talking about their ideas, things start getting complicated. Students often introduced naïve and incorrect ideas about phenomena in the world. When those ideas involved real-world contexts, discussions became even more complicated. And yet if the subject matter were constrained, the result would also likely constrain opportunities for joint construction. This creates a dilemma

for teachers in terms of thinking about students' abilities and needs and juxtaposing those with the value of real experiences with phenomena in the world that are based on complex phenomena requiring complex accounts.

However, the conclusions for practice are far more interesting in my estimation. When I have talked with teachers about classroom science talks, many respond suggesting that it is a common part of their practice. However, when visit their rooms, the complexity is either missing or goes unexamined. They think they are having their students have science talks or they ask me, so what do you think, what they should do next. Similarly with pre-service teachers, I have struggled with the book, Talking their way into Science (Gallas, 1995) because students read the book and fail to understand the complexity of holding a science talk with students. In either, in-service or pre-service teachers, one problem that I perceive is that they focus on one of the dimensions of the theoretical model described here, usually to the exclusion of the others. As a result they oversimplify the context, leading to distorted participant frameworks that do not adequately respond to the dynamic, flexible context that is a natural part of learning contexts (Duckworth, 1996).

This problem is even more complex when thinking about the role of human agency. Throughout this study my analysis often led me to becoming critical of students accounts because of their introduction of agency. I tended to interpret that since they were not using model based reasoning, then the account

was not scientific. This is inaccurate and also useless conclusion since scientists are interested in practical accounts as well as model-based accounts. However, I am an exception in thinking about students discussions. I think in-service and pre-service teachers make similar faulty assumptions that by having students talk and especially if they talk about their ideas, the result is scientific. And yet these findings suggest that students do not engage in model-based reasoning which is a goal for students in science learning (American Association for the Advancement of Science, 1993; National Research Council, 1996). So this is also not an acceptable outcome. In short, the key is that this is more complex than we often think.

Students resources to jointly construct accounts

The final issue this writing has raised is considering the available linguistic abilities that students bring to discussions. These abilities impact the ways that students can participate, speak, and know in discussions. Students having more resources are advantaged in the discussion context.

There is an implicit assumption that language is important to understanding the world. Does this mean someone that speaks well knows more? The problem is, especially with young students' science learning, that students lack vocabulary and may even lack the ability to use language to tell what they think or understand. Thus students' abilities with language become resources for students in discussions. The important question in this study is whether such resources influenced students' abilities to participate. I raise this as a question to consider because of tendency to want to focus on vocabulary in

science. The thinking is that students need those particular words to be able to construct accounts of phenomena. However, this data suggests that this was not the case. There were times when students might have benefited from having more robust vocabularies. However, it did not seem to infringe on their ability to communicate or act in a context.

Another resource in discussions involves thinking about the issue of the representation used in the wind and kites talk. This seemed to support some sense-making for students. My interactions in this context might have adversely impacted the discussion context. However, I think the drawing was valuable for students helping them manage portions of the account so that they could focus on other portions of the account. Again this becomes a question of managing dilemmas relevant to teaching. The question in terms of resources is; how representations serve in different contexts to support student thinking?

Finally, the question of developmental appropriateness might have important impacts in terms of resources. We know that students develop different abilities over time. So the question is; do those abilities also impact the ways that they can participate in discussions? This study does not necessarily support this since the students represent a wide range of developmental abilities. The data set included special education and gifted students in three grade-levels talking to one another. Yet, this is a somewhat unsatisfying answer. We do know that knowing some things helps you understand other things. The things we know mediate our knowledge and sense-making. So it seems logical that the ways of knowing that we possess and our development of ways of knowing

would impact the ways we can mediate new knowledge and different explanations. But that is a question and theory that can not be answered in this analysis.

Future Research

Describing the results of this study has raised a number of questions that still need further research. In this section I will briefly review those. Each serves as a bullet point of a larger set of research questions. Thus as with all inquiry these are first, next steps, drawn from this study.

A question that has been recurrent in my thinking involves thinking about strategies to help students learn to construct accounts. Some students were particularly skillful at taking up the comments of peers and working themselves into the discussion. This allowed them to situate their ideas in the context and become key participants. Students, who did not seem to possess those same uptake strategies, when they did speak, often introduced ideas that were not within the on-going thematic sequence or were hard to situate in the discussion. This raises a question about whether learning discussion strategies might support their involvement in discussions. However, teaching students discussion strategies may introduce a new challenge. The more students that participate, the greater potential there is to introduce naïve ideas. This becomes an empirical question drawn from the preceding notion.

My thinking in this work was profoundly affected by the examination of language. As I conducted analyses of semantic relationships and thematic patterns, I began to understand differently how my students were making sense

of phenomena. As a result I began to wonder about the value of helping teachers learn to use similar analyses as pedagogical tools to better understand the sense-making of their students. This introduces a number of questions about the practicality of learning and doing such analyses, the learning of teachers as they participated in such activity, and similar kinds of questions.

Another issue that has been on-going throughout the work is thinking about developmental trajectories of talk in science classrooms. Human agency was influential for students in my classroom and study. They were young elementary students. There is potential that human agency was a first step that these students were taking toward emergent science literacy. Their view was on the ways that human actions caused outcomes in the world. It might be possible, through other study designs to consider how students' language develops over time and through experiences to see what the trajectory of talk in science classrooms looked like.

Finally there has been the implication that mediation of complex accounts of phenomena may require support by some knowledgeable other. In the case of the wind and kites talk, I supported students with a drawing. It seems that it would be important in research to begin to think more carefully about the different ways that teachers can mediate learning in sense-making discussions in science

Bibliography

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

Anderson, C. (2001). Teaching for Understanding. Retrieved, 2003, from the World Wide Web: http://scires.educ.msu.edu/Science/Public/Assignments.htm

Anderson, C. W., Holland, J. D., & Palincsar, A. (1997). Canonical and Sociocultural Approaches to Research and Reform in Science Education. Elementary School Journal, 97(4).

Atkinson, P., & Hammersly, M. (1994). Ethnography and participant observation. In N. K. Denzin & Y. Lincoln (Eds.), Handbook of Qualitative Research (pp. 248-261). Thousand Oaks: Sage Publications.

Austin, J. L. (1999). How to do things with words. In A. Jaworksi & N. Coupland (Eds.), The Discourse Reader. London: Routledge.

Bakhtin, M. M. (1986). Speech genres & other late essays (V. W. McGee, Trans.). Austin: University of Texas Press.

Barnes, D., & Todd, F. (1995). Communication and learning revisited: Making meaning through talk. Portsmouth: Boynton/Cook Publishers, Inc.

Barton, A. C. (1998). Teaching science with children: Pedagogy, representation and identity. Journal of Research in Science Teaching, 35(4), 379-394.

Bazerman, C. (1988). Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science. Madison: University of Wisconsin Press.

Bianchini, J. A. (1997). Where knowledge construction, equity, and context intersect: Student learning of science in small groups. Journal of Research in Science Teaching, 34(10), 1039-1065.

Bloom, J. (2001). Discourse, Cognition, and Chaotic Systems: An examination of students' argument about density. The Journal of the Learning Sciences, 10(4), 447-492.

Cazden, C. B. (1988). Classroom Discourse: The Language of teaching and learning. Portsmouth: Heinemann.

Cobb, P., & Bowers, J. (1999). Cognitive and Situated Learning Perspectives in Theory and Practice. Educational Researcher, 28(2), 4-15.

Cobb, P., & Yackel, E. (1995). Constructivist, Emergent, and Sociocultural Perspectives in the Context of Developmental Research. Paper presented at the

Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Columbus, OH.

Cochran-Smith, M., & Lytle, S. L. (1999). The Teacher Research Movement: A Decade Later. Educational Researcher, 28(7), 15-25.

Collins, A., Brown, J., & Newman, S. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. Resnick (Ed.), Knowing, learning and instruction: Essays in honor of Robert Glaser. (pp. 453-494). Hillsdale: Lawrence Erlbaum Associates.

Coulthard, M. (1985). An introduction to discourse analysis (Second ed.). Essex: Pearson Education Limited.

Crawford, T., Kelly, G. J., & Brown, C. (2000). Ways of knowing beyond facts and laws of Science: An ethnographic investigation of student engagement in scientific practices. Journal of Research in Science Teaching, 37(3), 237-258.

Darrelson, D. (1985). On the very idea of a conceptual scheme. In H. Rajchman & C. West (Eds.), Post-Analytic philosophy (pp. 129-143). New York: Columbia University Press.

Duckworth, E. (1996). The having of wonderful ideas and other essays on teaching and learning. New York: Teacher's College Press.

Edelsky, C. (1993). Who's got the floor? In D. Tannen (Ed.), Gender and conversational interaction (pp. 189-227). New York: Oxford University Press.

Enfield, M. (2000a). Do you know what you are talking about? Teacher content knowledge in elementary classroom discourses. Paper presented at the National Association for Research on Science Teaching Annual Conference, New Orleans, LA.

Enfield, M. (2000b). Who's talking, who's listening: Social constructivist science learning facilitated by classroom talk. Paper presented at the American Educational Research Association Annual Conference, New Orleans, LA.

Feynman, R. P. (1994). Six easy pieces. Reading: Perseus Books.

Gallas, K. (1995). Talking their way into science: Hearing children's questions and theories, responding with curricula (1 ed.). New York: Teachers College Press.

Gee, J. P. (1991). What is literacy? In C. M. a. K. Weiler (Ed.), Rewriting literacy: Culture and the Discourse of the Other. Westport: Bergin & Garvey.

Gee, J. P. (1997, March 1997). Science talk: Language and knowledge in classroom discussion. Paper presented at the Annual Meeting of the National Association fo Research on Science Teaching, Chicago.

Geertz, C. (1973). The interpretation of cultures. New York: Basic Books.

Glaser, B., & Strauss, A. (1967). The discovery of grounded theory: Strategies for qualitative research. New York: Aldnine.

Grice, H. P. (1999). Logic and conversation. In A. Jaworski & N. Coupland (Eds.), The Discourse Reader.

Heath, S. B. (1983). Ways with Words: Language, life, and work in communities and classrooms. Cambridge: Cambridge University Press.

Hilton-Brown, B., & Kelly, G. J. (2001). Discourse studies of science education: A review of the literature. Paper presented at the National Association for Research in Science Teaching Annual Meeting, St. Louis, MO.

Hogan, K., Nastasi, B. K., & Pressley, M. (2000). Discourse patterns and collaborative scientific reasoning in peer and teacher-guided discussions. Cognition and Instruction, 17(4), 379-432.

Hulland, C., & Munby, H. (1994). Science, stories and sense-making: A comparison of qualitative data from a wetlands unit. Science Education, 78(2), 117-136.

Jaworski, A., & Coupland, N. (1999). Perspectives on discourse analysis. In A. Jaworski & N. Coupland (Eds.), The Discourse Reader. London: Routledge.

Kawagley, A. O., Norris-Tull, D., & Norris-Tull, R. A. (1998). The indigenous worldview of Yupiaq culture: Its scientific nature and relevance to the practice of teaching science. Journal of Research in Science Teaching, 35(2), 133-144.

Kelly, G. J., & Chen, C. (1999). The sound of music: Constructing sciecne as sociocultural practices through oral and written discourse. Journal of Research in Science Teaching, 38(8).

Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. Science Education, 77(3), 319-337.

Kurth, L. A., Anderson, C., & Palincsar, A. S. (2002). The case of Carla: Dilemmas of helping all students to understand science. Science Education, 86(3).

Latour, B., & Woolgar, S. (1986). Laboratory life: The construction of scientific facts. Princeton: Princeton University Press.

Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press.

Lee, O., & Fradd, S. H. (1996). Literacy Skills in Science Learning among Linguistically Diverse Students. Science Education, 80(6), 651-671.

Lee, O., & Fradd, S. H. (1998). Science for All, Including Students from Non-English-Language Backgrounds. Educational Researcher, 27(4), 12-21.

Lemke, J. L. (1990). Talking science: Language, learning and values. Norwood: Ablex Publishing Corporation.

National Research Council. (1996). National Science Education Standards. Washington DC: National Academy Press.

O'Conner, M. C., & Michaels, S. (1996). Shifting participant frameworks: Orchestrating thinking practices in group discussion. In D. Hicks (Ed.), Discourse, learning, and schooling. New York: Cambridge University Press.

Perkins, D. (1998). What is understanding? In M. S. Wiske (Ed.), Teaching for Understanding: Linking research with practice. San Francisco: Jossey-Bass Inc.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of scientific conception: Toward a theory of conceptual change. Science Education, 66(2), 221-227.

Quine, W. V. O. (1953). Two Dogmas of Empiricism, From a logical point of view (pp. 20-46). Cambridge: Harvard University Press.

Rath, A., & Brown, D. E. (1996). Modes of engagement in science inquiry: A microanalysis of students' orientation toward phenomena at a summer camp. Journal of Research in Science Teaching, 33(10), 1083-1097.

Reddy, M., Jacobs, P., McCrohon, C., & Herrenkohl, L. R. (1998). Creating scientific communities in the Elementary classroom. Portsmouth: Heinemann.

Rogoff, B. (1995). Observing sociocultural activity on three planes: participatory appropriation, guided participation, and apprenticeship. In J. V. Wertsch & P. D. Rio & A. Alvarez (Eds.), Sociocultural studies of the mind (pp. 139-164). New York: Cambridge University Press.

Rutherford, F. J., & Ahlgren, A. (1989). Science for all Americans. New York: Oxford University Press.

Scauble, L., Klopfer, L., & Raghavan, K. (1991). Students' transition from an engineering model to a science model of experimentation. Journal of Research in Science Teaching, 28(9), 859-882.

Shapiro, B. (1994). What children bring to light: A constructivist perspective on children's learning in science. New York: Teacher's College Press.

Smith, D. C., & Anderson, C. (1999). Appropriating scientific practices and discourses with future elementary teachers. Journal of Research in Science Teaching, 38(7).

Smith, E. L. (1990). A conceptual change model of learning science. In S. Glynn & R.Yeany & B. Britton (Eds.), Psychology of Learning Science (pp. 43-63). Hillsdale: Lawrenece Erlbaum.

Traweek, S. (1988). Beamtimes and lifetimes: The world of high energy physics. Cambridge: Harvard University Press.

Vygotsky, L. (1986). Thought and Language. Cambridge: The MIT Press.

Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A. S., & Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday senes-making. Journal of Research in Science Teaching, 38(5), 529-552.

Watson, B., & Konicek, R. (1990). Teaching for conceptual change: Confronting children's experience. Phi Delta Kappan, 71(9), 680-685.

Weiner, L. (2000). Research in the 90': Implications for urban teacher preparation. Review of Educational Research, 70(3), 369-406.

Appendices

Appendix A

The following descriptions and transcripts of discussions constitute the discussions that were analyzed in this study. Non-consenting students are represented in the transcripts as "NC" or blank spaces in individual utterances. This was done to preserve the sequence of the discussion and provide anonymity for those students. From this set of selected discussions the two focal discussions that were used in this dissertation are identified.

8) Cloud Talk – May 5, 2001

This discussion, on the nature and composition of clouds, lasted 20 minutes, resulting in 416 lines of transcript. The selection came from a longer discussion about clouds that lasted over 40 minutes. The discussion began by reading "The Cloud Book" by Tomi DePaula, which includes scientific and cultural ideas about clouds. After establishing norms for the discussion, Stephan was first to speak. He said that clouds are made of tiny drops of water suspended in the atmosphere (line 4). This definition was a near identical repetition of the definition provided on the first page of the cloud book. I restated this definition of clouds in the next turn. In line 35, Darrel asked the question that became the focus on the next 17 minutes. He wanted to know, "how could clouds be made of water?"

Stephan responded first to this question. He began telling about how "rain isn't just from clouds (line35)," but explained that "clouds [...] raise up water" that can't be seen (line 40). This idea about raising water was repeated throughout the discussion by Stephan and Darrel (lines 49, 111, 275, 282,286, 287, 294, and

300). They both talked about ways the water rose without being seen (lines 49, 309, and 311). I restated my interpretation of Darrel's question, "where does the water come from (line 63)?" Darrel responded asserting, "That water come from the lakes and the ocean (line 69)." Stephan joined, to repeat his ideas describing the movement of water from the ground to the atmosphere (line 72). Bobby asserted that water comes from Jesus (line 85).

Many students focused on phenomena associated with clouds. Stephan introduced rain saying, "when the cloud gets clumped up with too many rain drops, then it rains (line 50)." Lora interpreted Stephan's idea saying that clouds get "really heavy with water" and then rain (line 95). Darrel mentioned rain 12 times and snow (line 223) as coming from clouds. In contrast, Darrel talked about how "the cloud sucks up the water once it gets real cool it starts to rain (line 111)." Darrel added additional phenomena, saying dark clouds led to rain (line 175-177) and claimed that it rains mostly at night. Rodger also talked about rain (line 182) telling how it came at night and made the ground muddy.

An interesting portion of this discussion was the analogies for clouds (and potentially rain) that students developed. All of these analogies involved actions of human agents and treated clouds as semi-solid objects that absorb and precipitate water. Stephan initiated the analogies by talking about making brownies (line 120) to explain how clouds could overflow, which Darrel accepted (line 124). Stephan altered the analogy to a sponge (line 125). I asked students to say whether a cloud was more like a sponge or a bowl. Darrel thought it was both, and while explaining his analogy added a third possibility, cotton (line 133).

However, the sponge analogy seemed most resilient. Bobby validated the notion that sponges and clouds both hold water (line 146 & 149). Stephan built on the sponge analogy describing how it explained water movement to clouds and clouds holding water (line 151 & line 163-167). Darrel held to his idea that sponges and bowls were necessary to explain clouds (lines 171-177). Darrel was not satisfied with the analogy and developed another analogy, that a spaceship with a sucking straw as an analogy for how water got into clouds (lines 275-294). But Stephan rejected this, asking, why "you do not see all that water being sucked up (line 304)." Darrel countered Stephan saying that, "I'm just going with your idea (line 308)," referencing Stephan's explanation about water being sucked up.

At the prompting of a question by Mrs. C., which came after Darrel's claim about temperature (line 203), the students began talking about the relationship between temperature and cloud formation. Darrel was confident that it needed to be cold (lines 204, 206). Marquisha disagreed, though not publicly (line 215), simply saying "warm." Stephan included warm and cold temperatures as necessary to cloud formation (line 218). Later he used examples of precipitation in summer and winter as evidence that the temperature was not relevant (line 290). Lora produced the most scientific response to Mrs. C.'s question, explaining that her mother told her that warm and cold air "comes together and it turns into rain (line 228)."

At the end of the discussion there was no clear conclusion about the students' explanations of clouds. They developed a series of analogies that each

had weaknesses. The final portion of the discussion involved Stephan challenging Darrel's spaceship analogy. Stephan challenged a portion of Darrel's analogy, which as Darrel pointed out was built on Stephan's claim.

Darrel and Stephan dominated this discussion, most of the student utterances. Furthermore, most of the shared utterances also referred to Stephan and Darrel's utterances, most of which came from one another.

Line	Speaker	Utterance
1.	Mr. E.	So we are going to talk one person at a time
2.	Mr. E.	and try to say short things so that everyone has a chance to talk. //
3.	Mr. E.	Stephan
4.	Stephan	Clouds are made of little drops of water or ice hanging in the air /
5.	Stephan	in the atmosphere
6.	Mr. E.	OK
7.	Mr. E.	So Stephan says clouds are made of little drops of water or ice hanging in the air
8.	Stephan	the atmosphere
9.	Mr. E.	in the atmosphere //
10.	Mr. E.	Marquisha is that what you were going to say also^
11.	Marquisha	I don't know
12.	Mr. E	Does anybody
13.	unknown	you don't know *some other talk*
14.	Rodger	Well why did you raise your hand^
15.	Mr. E.	OK / _____ has something else
16.	Bobby	No she don't *without permission to speak*
17.	NC	
18.	Mr. E.	I'm sorry _____ you have to stop a minute//
19.	Mr. E.	I don't think that anybody is listening to _____ but maybe Stephan and Marquisha and Octavia //
20.	Mr. E.	Rodger / _____ and Bobby and Kelvin I need to focus your attention on listening to _____ right now//
21.	Mr. E.	Go _____.
22.-25.	NC	
26.	Mr. E.	OK
27.	Mr. E.	_____ talked about what clouds tell us//

28.	Mr. E.	But right now lets focus just on/ lets try to think about
29.	Mr. E.	what are clouds are made of//
30.	Mr. E.	Stephan said clouds were made of tiny drops of water and ice in the atmosphere//
31.	Mr. E.	How many people agree with that^ *some students raise their hands*
32.	Darrel	I got something
33.	Mr. E.	Great/ OK Darrel you have something else^
34.	Darrel	I agree with Stephan/ because that //
35.	Darrel	how could / *long pause*/clouds be made of water^
36.	Mr. E.	OK //
37.	Mr. E.	Darrel's got a great question /
38.	Mr. E.	"how could clouds be made of water^" //
39.	Mr. E.	Stephan^
40.	Stephan	Because sometimes umm when it / umm / rains the rain isn't just from the clouds//
41.	Stephan	Clouds sometimes umm raise up water but you can't see it because it is very light and it comes up and when it gets umm
42.	Mr. E.	Stephan you need to wait a minute//
43.	Mr. E.	There is a little rustling over here that is distracting me//
44.	Mr. E.	So I just wanted you to wait/
45.		*Some management and arranging of students*
46.	Mr. E.	Ok Stephan / try again//
47.	Stephan	How // How water drops get up in the air in the atmosphere is because when it /
48.	Stephan	during the day /
49.	Stephan	clouds they bring up little drops of water clouds that are so small that you can't see them and they go so fast that you can't see them either
50.	Stephan	and so when a cloud gets clumped up with too many rain drops/ then it rains//
51.		*Some more management*
52.	Mr. E.	So those people that are having a hard time talking / I'm going to start sending back to their desks//
53.	Mr. E.	That means listening and talking//
54.	Mr. E.	Bobby did you want to say something^
55.	Bobby	How come Kelvin got all those pencils^
56.	Mr. E.	Because Mrs. Corbin has asked him to put them away and he hasn't followed her instruction//

57.	Mrs. C.	So I am going to give him one minute and if he doesn't put the other two pencils in the center and start paying attention he will be going back and writing sentences//
58.	Mrs. C.	In the center of the carpet *response to Kelvin's move*
59.	Mr. E.	I think there are three pencils//
60.	Mr. E.	So we have this idea that there's water //
61.	Mr. E.	_____ could you sit down^
62.	Mr. E.	We have this idea that clouds are made of water / *long pause* / small drops of water /
63.	Mr. E.	but where does that water come from^
64.	Mr. E.	Is there just water in the air?
65.	*unclear*	*Overlapping chorus* NO
66.	NC	
67.	Mr. E.	*Response to NC student*
68.	Mr. E.	Where is that water coming from^
69.	Darrel	That water come from the lakes and the ocean
70.	*unclear*	the clouds
71.	Darrel	because Stephan had said its like
72.	Stephan	the water comes so fast its in tiny pieces and you can't see it
73.		*Multiple overlapping voices make it difficult to make out.*
74.	Mr. E.	Just a minute//
75.	Mr. E.	Darrel /
76.	Mr. E.	we have little conversations going /
77.	Mr. E.	and I know that you have some ideas/
78.	Mr. E.	but we need to make it so that everybody can hear everybody's comments//
79.	Rodger	Bobby's know it
80.	Mr. E	So/ Bobby you waited /
81.	Mr. E	Bobby what were you going to say about clouds / or the water^
82.	Mr. E	You were going to say something about the water / right^
83.	Bobby	Yep
84.	Mr. E.	What were you going to say^
85.	Bobby	Water comes from / pause / Jesus.
86.	Mr. E	The water comes from Jesus //
87.	Mr. E	OK
88.	Darrel	Jesus^
89.	Mr. E.	Jesus//
90.	NC	
91.	Mr. E.	Lora

92.	*multiple*	*overlapping talk*
93.	Lora	[*In audible, overlapping talk]*
94.	Mr.E	I'm sorry I didn't hear you _____ said something right in the middle of what you were saying so I couldn't hear you
95.	Lora	I really don't know what I'm talking about
96.	Mr.E..	That's alright most of us don't
97.	Mrs. C.	But I / I thought what you said was interesting so try to say it again //
98.	Mrs. C.	because I was writing it down
99.	Lora	When the clouds are really heavy with water/ umm it starts to rain//
100.	Mr. E.	When the clouds are really heavy with water is starts to rain^
101.		*gesture from Lora to agree*
102.	Mr. E.	OK
103.	Darrel	Oh I think I know why it have // Oops
104.	Mr.E.	Yeah Darrel
105.	Darrel	I think I know why it has water in it//
106.	Darrel	I mean it rains.
107.	Darrel	Its almost like the idea of Stephan had//
108.	Darrel	But I drew a picture here about what Stephan had said / and I thought about it / and was//
109.	Darrel	Its kind of like kind of / Lora's and Stephan's
110.	Darrel	but I think /when the water sucks up/
111.	Darrel	I mean the cloud sucks up the water once it gets real cool it starts to rain and when its /
112.	Darrel	when like/ when like the water's done/ it just//
113.	Darrel	It turns dark when the water comes up then it turns light it floats like into / in the cloud//
114.	Darrel	Then when it /starts raining//
115.	Darrel	Then when the clouds get light there's / it's gonna be sun//
116.	Darrel	I don't know what I'm talking about here//
117.	Mr. E.	That sounded good//
118.	Mr. E.	what Stephan^
119.	Stephan	I think what Darrel is trying to say is that the clouds get filled up with too much / too much rain drops/ they over flow *drawn out //*
120.	Stephan	like lets say you are making brownies and you overflow it/
121.	Stephan	like you overflow something like a faucet it's the same thing as water overflowing
122.	Stephan	and umm/ the water falls into little drops

123.	Mr. E.	So you're saying the cloud is like a big bowl that holds water^
124.	Darrel	Yea, like a bowl that holds noodles and something.
125.	Stephan	Yea, its like a big sponge//
126.	Darrel	Its like a big sponge//
127.	Bobby	Its like a big sponge
128.	Mr. E.	Hang on//
129.	Mr. E.	OK so there is one idea of a bowl//
130.	Mr. E.	And then Stephan threw in this idea of a sponge, which one seems
131.	Darrel	its both because it holds water and then it could squeeze and it could and water could come out of because
132.	Mr. E.	Hang on, let's let
133.	Darrel	its real like umm/ its almost like cotton/
134.	Darrel	once you/ like how when you get a cotton ball and dump water on it/
135.	Darrel	and you squeeze it/
136.	Darrel	some water will come out/
137.	Darrel	but if you don't squeeze it there's still water coming out and it will have water still on it and water will come out.
138.	Mr. E	People that are scribbling in their books right now / that really distracts me//
139.	Mr. E	If you are taking notes in your notebook I am very happy about that
140.	NC	
141.	Mr. E.	If you are scribbling that really is distracting//
142.	Mr. E	Bobby/
143.	Mr. E	If you are drawing pictures of clouds that would be OK//
144.	Mr. E	If you are drawing pictures of little boys and girls doing different things that's not going to help//
145.	Mr. E	Bobby/ what were you waiting to say^
146.	Bobby	Sponges can hold water//
147.	Mr. E.	Sponges can hold water//
148.	Rodger	Sure can
149.	Bobby	*Some overlapping talk* and clouds can too//
150.	Mr. E.	OK Stephan
151.	Stephan	I think a cloud is more of a sponge because if you put a sponge in water its not going to get no water in it//
152.	Stephan	But if you squeeze it in the water
153.	Mr. E.	Just a minute/ I'm sorry can you wait^
154.	Mr. E.	Rodger

155.	NC	
156.	Mrs. C.	Maybe Rodger needs to go back and write sentences//
157.	Rodger	nuh-uhh
158.	Mrs. C.	This is your last chance//
159.	Mrs. C.	The next time you are disturbing somebody / or anybody is disturbing anybody / you will be writing sentences//
160.	Mr. E.	Now I / before Stephan goes on / I know everybody here knows a lot about clouds / but we only have about five people talking//
161.	Mr. E.	So I think that some of the rest of you could help us figure this out//
162.	Mr. E.	Stephan / go ahead
163.	Stephan	umm / I think a cloud is more of a sponge because if you just lay a sponge in water it just floats /
164.	Stephan	but if you squeeze it / it goes in the water and it sinks//
165.	Stephan	As it is sinking it soaks up the water//
166.	Stephan	Then if you take the water out / then it will still drip because of the water that is outside of it//
167.	Stephan	But if you squeeze it / umm /all the water will squeeze out and it will look like sort of like rain//
168.	Mr. E.	Ok / Darrel
169.	Rodger	I was next
170.	Mr. E.	Darrel was waiting first
171.	Darrel	Its like/ I think it' like both of them / a bowl and a sponge//
172.	Darrel	Because once it gets the water from the ocean or the lake it becomes like a bowl
173.	Darrel	And it'll do something and then it'll turn into a sponge it'll like make it rain because when it//
174.	Darrel	I don't know what I am saying /
175.	Darrel	but when it umm gets dark and stuff / like dark /
176.	Darrel	like it mostly rains at night.
177.	Darrel	When it gets dark at night / then the clouds / like the clouds get dark and black and it starts raining
178.	Mr. E.	OK / Rodger / you wanted to say something a minute ago
179.	Bobby	I made it thunder once shooting fireworks
180.	Mr. E.	You need to wait because Rodger has been waiting patiently to talk
181.	Rodger	Umm / one time / sometimes when clouds break / it starts raining /
182.	Rodger	And then in night time / it be soaking wet //

183.	Rodger	And then be mud puddles//
184.	Mr. E.	And then what happens in the day to the mud puddles?
185.	Rodger	Huh^
186.	Mr. E.	What happens in the day to the mud puddles^
187.	Rodger	Umm / if the sun show up / they dry up / but it still be muddy//
188.	Mr. E.	So there is something going on with the sun that is important too I guess.
189. - 190	NC	
191.	Mr. E.	
192.	NC	
193.	Mr. E.	OK //
194.	Mr. E.	So / that's another idea//
195.	Mr. E.	Yeah Marquisha
196.	Marquisha	Are we talking about how to make clouds^
197.	Mr. E.	Well right now I was hoping we could talk about what are clouds are made of //
198.	Mr. E.	And then/ hang on Marquisha I am going to finish answering your question//
199.	Mr. E.	And then once we figure out what clouds are made of / then we can try to figure out a plan to try to make a cloud.
200.	Marquisha	To make a cloud^
201.	Mr. E.	We are going to see if we can make a cloud inside our classroom// *lots of overlapping talk* not the whole room //
202.	Mr. E.	Maybe we could try to make a cloud maybe in a bottle
203.	Mrs. C.	I wonder if it have to be warm for clouds to be made or does it have to be cold^
204.	Darrel	It has to be cold
205.	Mrs. C.	Or either one
206.	Darrel	It has to be cold to make the clouds//
207.	Mr. E.	OK Darrel / you are yelling out //
208.	Mr. E.	There were three people that wanted to talk at the same time because I saw Marquisha's hand go up and then come back down and then Lora's hand now is going up //
209.	Mr. E.	Mrs. Corbin has a really great question//
210.	Mrs. C.	I honestly don't know the answer to it//
211.	Mr. E.	Who wants to take on Mrs.Corbin's question^
212.	Stephan	What was the question again^

213.	Mrs. C.	My question was a wondered if it had to be warm to make clouds / or cold to make clouds or do both kinds of things need to happen //
214.	Mr. E.	Let's start with Marquisha because she hasn't had a chance to talk much yet//
215.	Marquisha	warm //
216.	Mr. E.	warm //
217.	Mr. E.	Uhh Stephan//
218.	Stephan	I don't really think it matters what the temperature is /
219.	Stephan	because in summer we have clouds and in winter also have clouds and get snow//
220.	Mr.E.	OK / Darrel
221.	Darrel	I think it rains /
222.	Darrel	I mean I think its cold because if it gets cold / like real cold /
223.	Darrel	if it was below something / zero below something / it'll start to snow//
224.	Darrel	But it will if it is above 40 it will rain and snow because rain turns into snow//
225.	Mr. E.	OK / Lora
226.	Lora	I have a different question//
227.	Mr. E.	Ohh / let's hear it//
228.	Lora	You know the cold air and hot air^
229.	Lora	It comes together / it comes together and it turns into rain//
230.	Mr. E.	Where did you learn that^
231.	Lora	My Mom//
232.	Mr. E.	Ohh /
233.	Mr. E.	the cold air and the hot air comes together and it makes rain//
234.	Mr. E.	Bobby and Rodger / I don't / I'm not sure that what you're doing is right on target <u>with what we are doing</u>//
235.	Rodger	<u>We drawing clouds</u>//
236.	Mr. E.	Stephan
237.	Stephan	I have something for wind //
238.	Mr. E.	For what / for wind^
239.	Stephan	I have something about wind//
240.	Mr. E.	We are going to do wind//
241.	Mr. E.	Yea we'll do wind//
242.	Mr. E.	Molefi
243.	Mr. E.	*After a pause* _____^
244. - 249	NC	

250.	Mr.E.	OK / Lora
251.	Lora	What makes lightning?
252.	Mr. E.	What makes lightning//
253.	Mr. E.	That's a big question//
254.	Mr. E.	You know what ^
255.	Mr. E.	We'll try to figure that out//
256.	Mr. E.	Let's focus just on clouds right now//
257.	Mr. E.	Mrs. Corbin, asked a really important question I think about does it have to be warm or cold
258.	Kelvin	*jumping in* cold
259.	Mr. E.	Now Kelvin says cold *several other students jump in and call out answers*
260.	Mr. E.	Let me see hands for people who think it has to be warm to make a cloud//
261.	Mr. E.	Let me see hands for people who think it has to be cold to make a cloud//
262.	Mr. E.	Well Jasmine, your hand stayed up both times//
263.		Why do you...
264.	NC	
265.	Mr. E.	*Redirect to NC student*
266.	Mr. E.	Just a minute Stephan
267.	NC	
268.	Mr. E.	*Redirect to NC student*
269.	Mr. E.	Stephan//
270.	Stephan	It needs both because if it was only warm then there would be no such thing as snow because snow is a cold temperature and you would need a cold temperature to make snow//
271.	Mr. E.	OK / so Stephan has an example//
272.	Mr. E.	Stephan has given us an example as evidence for why you need both//
273.	Darrel	I think I know why
274.	Mr. E.	Darrel
275.	Darrel	You know how spaceships have this thing to umm / like special types of laser things to bring people up in their spaceship^
276.	Darrel	Like that^
277.	Stephan	He's talking about alien ship on the TV//
278.	Darrel	Yeah /
279.	Darrel	But I think /
280.	Darrel	This is weird
281.	Darrel	but I think they have a straw like a straw to rain out
282.	Mr. E.	Ohh/ so the straw brings the water up / so you are making the laser beam like a staw //
283.	Mr. E.	Is that what you are saying^

284.	Darrel	Yeah /
285.	Darrel	not the laser beam but like a straw because I drew a picture like this//
286.	Darrel	And here goes the earth and its sucking some water up from it and once it gets real filled up in here /
287.	Darrel	once it gets about half way filled / the straw comes up and it starts to rain//
288.	Darrel	the straw comes up and it starts to rain//
289.	Darrel	And then that's why they get floods and stuff / because it sucks up too much water and rain//
290.	Darrel	You didn't hear what I said Mrs.Corbin^
291.	Mrs. C.	No I was trying to talk to Bobby//
292.	Darrel	You know how they have spaceships on TV^
293.	Darrel	And they have those laser things/ to bring people up//
294.	Darrel	I made something like this shows his drawing that has got a straw / like / got a straw to suck out water to get up in here once it has to get full it starts to pour out rain and stuff all over that's why it becomes floods and stuff//
295.	Mr. E.	What does the laser part do to the water^
296.	Bobby	Sucks it up
297.	Darrel	Sucks it up//
298.	Darrel	It makes like / It makes the water pump like little //
299.	Darrel	A whole bunch of water coming up//
300.	Darrel	And once it gets all filled / it starts to pour out//
301.	Mr.E.	So / yeah
302.	Stephan	But Darrel / if there was like a little straw from
303.	Darrel	imaginary straw
304.	Stephan	ohh / a cloud and it soaked up a whole bunch of water / then how come you could never see that whole bunch of water ^
305.	Darrel	huh^
306.	Stephan	How come you would never be able to see that whole bunch of water^
307.	Darrel	You said it comes up like //
308.	Darrel	I'm just going with your idea//
309.	Darrel	Because you said that it goes up real fast because / like there could be a
310.		*Audio glitch, at the same moment Darrel and Stephan talk over one another*
311.	Darrel	But it will go up fast / for people won't see it / it's real light like you said / you said the water is real light ^
312.	Stephan	But what I meant by that was it was just tiny drops and they went one by one//

313.	Stephan	But if it were gathered up/ it would make a stream of water//
314.	Darrel	I Know I said it will go up like little drops of water at a time
315.	Mr. E.	Just a minute/ lets let them figure this out
316.	Darrel	it was / it will suck up a little drop of water at a time.
317.	Mr. E.	He's using the straw as a / I think as a metaphor /
318.	Mr. E.	what you might call a metaphor//
319.	Mr. E.	So we know what a straw is //
320.	Mr. E.	And we can get an idea in our head
321.	Multiple	*overlapping*
322.	Darrel	when you drink something
323.	Stephan	science journals
324.	Darrel	Like when you drink some water / you have to have a straw / because the ice will melt into water and that's how you //
325.	Darrel	I think this is how they make ice//
326.	Darrel	From clouds with snow //
327.	Darrel	And they / put some water on the clouds to make it like real hard / they had to put it in the freezer //
328.	Mr. E	OK / we have got to wait a minute //
329.	Mr. E	Because _____ has been waiting a very long time/ and I think she wants to get into this conversation about the straw//
330.	Mrs. C.	And LaDale too//
331.	Mr. E.	Oh / LaDale too
332.	Mrs. C.	He's got an idea he wants to ask//
333.	Rodger	I do too//
334.	Mr. E.	_____^
335.	NC	
336.	Mr. E.	
337. - 339	NC	
340.	Lora	*Response to NC student question*
341.	Stephan	*Response to NC student question*
342.	Lora	I don't know//
343.	Mr. E.	It's a good point//
344.	Mr. E.	We will try to explain that _____//
345.	Darrel	Its time for lunch now//
346.	Mr.E.	LaDale / lets listen to LaDale//
347.	LaDale	*inaudible*
348.	Mr. E.	I don't think people heard you / your question so I need everybody to be quiet//
349.	Mr. E.	Because LaDale doesn't have a big voice like some of you do //

350.	Mr. E.	But LaDale has an important question//
351.	Mr. E.	So lets all listen and LaDale use your biggest voice to say the question again
352.	LaDale	How do you make snow^
353.	Darrel	How do you what^
354.	*Multiple*	Make SNOW
355.	Darrel	You make snow like how
356.	Stephan	raise your hand
357.	Mr. E.	Thank you Stephan//
358.	Mr. E.	Darrel
359.	Darrel	Stephan had his hand up first so he can go//
360.	Stephan	Umm / I don't think you can really make snow on earth //
361.	Stephan	but I believe / umm / snow / from a cloud is made from / if it's a really cold temperatures//
362.	Stephan	As the water drop falls / it freezes /
363.	Stephan	but as it gets closer to ground / the faster it goes /
364.	Stephan	the more ice of it melts away and it starts to turn into like a puffy type thing//
365.	Mr.E.	OK / Darrel
366.	Darrel	you know how that book said
367.	Rodger	I had one too
368.	Darrel	*continuing* there was like snow on mountains ^
369.	Darrel	I think its almost the same thing /
370.	Darrel	like the picture I drew over here / saying that there's a straw sucking up the water /
371.	Darrel	but this page I put it like here go the mountain /
372.	Darrel	*pointing to science journal* and its just that you know how they say north pole^
373.	Mr.E.	Mmm-hmm / you need to talk to LaDale though / because LaDale asked this question / I didn't
374.	Darrel	*directed at LaDale* You know how they talking about the north pole^
375.	Darrel	I don't know what I'm talking about
376.	*Multiple*	*laughing*
377.	Mr.E.	OK / lets see we can
378.	Rodger	*interrupting* I got one
379.	Mr. E.	Just a minute / I want to say something real fast //
380.	Mr. E.	We're going to do three more people / Marquisha / _____ and Rodger//
381.	Mr. E.	Now the problem is we are running out of time//
382.	Mr. E.	And also people have been sitting a long time//
383.	*Multiple*	*lots of student overlapping talk*
384.	Mr. E.	*trying to regroup* Marquisha what's your comment or question

385.	NC	
386.	Marquisha	umm / I was thinking about something / I forgot it
387.	Mr. E.	We'll come back to you / Rodger what's yours^
388.	Rodger	Umm / I got something about the ice part that Darrel said//
389.	Mrs. C.	Darrel / he's talking about something your idea //
390.	Mrs. C.	Listen to what he said
391.	Rodger	*picking up in the middle* said about the ice//
392.	Rodger	OK // *long pause*
393.	Rodger	Ice is made of water and then you put it inside the freezer//
394.	Rodger	Because the water is cold //
395.	Rodger	And in the freezer its cold//
396.	Rodger	So the freezer make the water turn into because they both is solids//
397.	Darrel	*jumping in* They made the snow from the / they made water from snow//
398.	Darrel	They made water from snow//
399.	Bobby	*without permission* snow will turn into water
400.	Mr.E.	_____
401.-405	NC	I'm going to add something to Darrel's//
406.	Mr.E.	OK / Marquisha
407.	Marquisha	Umm / when Stephan was talking about [unclear] it was [unclear]
408.	Marquisha	How to make ice / or something like that /
409.	Marquisha	and put err the ice tray /
410.	Marquisha	you put it in the freezer and it would freeze and you take it out and it makes ice and it's the freezer and its really cold //
411.	Marquisha	You put this water in it and then
412.	Darrel	*jumping in* I got a question / I got a question for you Marquisha
413.	Darrel	What made water ^
414.	Marquisha	God
415.	Mr. E.	We're asking big questions *there is an eruption of talk from several students.*
416.	Mr. E.	We have to stop now//

9) Wind and wind vanes – May 15, 2001

This selection lasted about 10 minutes, generating 73 lines of transcript. This selection was part of a longer discussion that attempted to help students

learn to describe wind direction and consider how wind affected objects. Students observed the effect of air movement on wind vanes in the context of the discussion. Since this was to be a teaching instance, I facilitated observations in the discussion to help students learn to read the wind vanes and understand that the wind vanes provided a way to describe wind direction.

In the context of the discussion Darrel (lines 8-13) stated that the wind vanes blew in the same direction. Breanne converted Darrel's statement to make the wind an active force on the wind vanes (line 46). Later, she returned to this generalization. In between these points Kelvin contributed to the discussion an element of human agency (line 37). He said the reason one wind vane might operated better was because I made it better.

Similar to the clouds discussion this discussion had no clear outcome. However, it was substantially different in a phenomenon (fans blowing on wind vanes) present for students to observe. Kelvin was the only student to introduce human agency in the discussion. However, the larger problem with this discussion was that only four students participated and of those only three received uptake.

line	Speaker	Utterance
1.	Mr. E.	I noticed that most of the time they were pointed towards which direction^
2.	Darrel	That *pointing* no I mean this way
3.	*multiple*	This way *gesturing*
4.	Mr. E.	And which way was the fan pointed^
5.	Darrel	The
6.	Marquisha	straight
7.	Mr. E.	So were they going different directions or the same direction as the fan^
8.	Darrel	different

line	Speaker	Utterance
9.	NC	
10.	Darrel	Well the fan was pointing this way *gesturing*
11.	Darrel	and they are pointing this way *gesturing*
12.	Mr. E.	So is it the same or different^
13.	Darrel	Same
14.-16	NC	
17.	Marquisha	The fan was going like
18.	Mr. E.	_____ what would you like to say?
19.-29	NC	
21.	*multiple*	huh / what^
22.	Mr. E.	tighter wave^
23.	Marquisha	tighter wave^
24.	NC	
25.	Mr. E.	Oh, the hole is looser there^
26.	NC	yes
27.	Mr. E.	OK
28.	Mr. E.	Come back down _____
29.	Mrs. C.	The others were tighter and yours was looser.
30.	NC	
31.	Mr. E.	Any other ideas^
32.	Mr. E.	Let me ask a diff...
33.	*unknown*	mmm
34.	Mr. E.	Oh Mari...
35.	Mr. E.	Oh my gosh
36.	Mr. E.	Kelvin first and then we'll hear what Breanne has to say
37.	Kelvin	The red one it's a loose
38.	Kelvin	cause you kind of make yours better than ours
39.	Mr. E.	OK
40.	Mr. E.	So you're saying its because I made it better
41.	Mr. E.	How about Breanne^
42.	Mr. E.	Breanne what were you going to say^
43.	Mrs. C.	Breanne what were you going to say^
44.	Breanne	The way the wind was blowing
45.	Breanne	The way the wind was blowing /
46.	Breanne	umm/ that's the way that the things were going.
47.	Mr. E.	The way the wind was blowing is the way that the things were going.
48.	Mr. E.	Now sometimes when scientists have an idea /
49.	Mr. E.	we just made an observation

line	Speaker	Utterance
50.	Mr. E.	and if we had a little more time I would make you go get your journals to write it down//
51.	Mr. E.	You notice how
52.	*unclear*	ewe
53.	Mr. E.	I said if we had more time
54.	Mr. E.	You notice how I used my journal this morning
55.	Mr. E.	That's what I was doing
56.	Mr. E.	I use my journal to help me remember information from observations
58.	Mr. E.	So we might write it down//
59.	Mr. E.	But another thing we can do is we could say /
60.	Mr. E.	I agree with what Breanne said
61.	Mr. E.	That the arrows blew in the same direction as the way the fan was blowing.
62.	Breanne	Cause if the wind is going that way *gesturing*
63.	Breanne	then the things is not going to go that way *gesturing*
64.	Breanne	because the wind is going that way *gesturing*
65.	Mr. E.	They are not going to turn this way *hold hand up flat in front of myself*
66.	Mr. E.	because the wind is blowing this way *point into the palm of my hand*
67.	Mr. E.	and it pushes them back around *move my flat hand to parallel with pointing hand*
68.	Mr. E.	is that what you are saying^
69.	Breanne	Mm-hmm
70.	Mr. E.	Is there anybody that disagrees with that^
71.	Darrel	Yes
72.	Mr. E.	How do you disagree with it Darrel^
73.	Darrel	*emphatically* I said agree

10)Wind and kites – May 15, 2001 - *Focal Discussion One*

This selection concluded the last 11 minutes (125 lines of transcript) of the discussion about wind vanes. This discussion intended to help students recognize that wind affects objects. To prepare for this discussion, I had created opportunities for students to play with kites during recess. Therefore all the students had multiple experiences with kites prior to this discussion.

I initiated the discussion asking students, "How do those kites work (line 4)?" The group gave a choral response "wind!" I responded that I needed to know more than wind, asking them to explain more. Bobby began saying that the string was important (line 13). Marquisha built on this delivering an extended narrative including human agents that described what sounded like a procedure for kite flight (lines 21-29). When I asked her to elaborate on her assertions, she got exasperated with me and said, "it just flies (line 29)!" Lora began (line 37) describing the roles of human agency in flying a kite. However, she converted this, combining preceding utterances, to say that when you have a string, the string prevents the kite from flying away (line 45). Rodger repeated this idea in an even more decontextualized statement (line 58).

At that point, I shifted the discussion asking students to consider a hypothetical situation of kites flying. I drew a kite and person on the board and asked students to describe the wind direction. Kelvin began, saying "this way" including a gesture (line 90). Darrel (line 96) and Felicity (line 114) made gesture based claims about the wind direction. However, the claims did not agree, so I suggested that we test our theories (line 122). This ended the discussion.

There was no resolved theory about kites and wind in the discussion. Several statements indicated the importance of human agency. However, this portion of the discussion involved significantly more student involvement. Seven students participated and six received some form of uptake in the discussion. This is roughly double the participation of the preceding portion of the discussion about wind vanes and double the number of students received uptake.

This became the first focal discussion, occurring on May 15, 2001 about kites and wind.

line	Speaker	Utterance
1.	Mr. E.	What has everybody been playing with that is so exciting and always want to take out at recess when we go outside^
2.	Darrel	kites
3.	Marquisha	kites
4.	Mr. E.	How do those kites work?
5.	multiple	WIND
6.	Mr. E.	Tell me a little more
7.	Mr. E.	I mean just the wind doesn't tell me how the kite works
8.	multiple	*overlapping talk, lots of excitement*
9.	Mr. E.	I need you to raise your hand
10.	Mrs. C.	Raise your hand
11.	Mrs. C.	he'll call on you if you are sitting flat and you have your hand raised
12.	Mr. E.	Bobby / how
13.	Bobby	the string
14.	Mr. E.	What about the string^
15.	Mrs. C.	Did you hear the question Bobby^
16.	Bobby	when the wind is running *unclear, interruption*
17.	NC	
18.	Mr. E.	So something about the string//
19.	Mr. E.	I'm not quite sure I understand but maybe we can keep working on it
20.	Mr. E.	Marquisha
21.	Marquisha	The reason how a kite flies *audio disruption*
22.	Marquisha	*beginning in middle of utterance* you make it
23.	Marquisha	and then put the string and stuff on it
24.	Marquisha	you get the string and you wind it in a big ball
25.	Marquisha	and you hang on to it

line	Speaker	Utterance
26.	Marquisha	and then you just run
27.	Marquisha	and it goes up in the air by the wind
28.	Marquisha	the wind blows and goes up in the air
29.	Marquisha	and it's flying
30.	Mr. E.	OK you've told me a good story about how
31.	Mr. E.	But I still don't understand how the kite is flying
32.	Marquisha	It just flies
33.	Mr. E.	Lora you had your hand up a minute ago//
34.	Mr. E.	Did you want to say something^
35.		NC
36.	*unclear*	All the kite
37.	Mr. E.	*to Lora*
38.	Lora	The wind /
39.	Lora	the string controls the kite
40.	Lora	so when you want to move it in different directions you have something to make it move in different directions
41.	Mr. E.	So the string sort of helps you to control the kite^
42.	Mr. E.	Is that what you said^
43.	Mr. E.	Just a minute Rodger
44.	Lora	If you want to fly a kite you have to have string
45.	Lora	When you have string it doesn't make it fly away
46.	Mr. E.	OK
47.	Mr. E.	I want to say something right now
48.	Mr. E.	Just a minute Rodger
49.	Mr. E.	A lot of you get frustrated when somebody says what you wanted to say//
50.	Mr. E.	But do you know what's really great about talks like this^
51.	Mr. E.	You can go /

line	Speaker	Utterance
52.	Mr. E.	You know what / I agree with so and so
53.	Mr. E.	I agree with Lora she had a great idea //
54.	Mr. E.	So instead of getting frustrated when and say /
55.	Mr. E.	You can say I agree
56.	Mrs. C.	that's right
57.	Mr. E.	Rodger / what were you wanting to say^
58.	Rodger	The string control the kite because for the kite to stay up in the air
59.	Rodger	First they make it out of wood
60.	Rodger	Then they get a / make a T or something
61.	Rodger	Then / like those other kites / they just have a little bit of thing
62.	Rodger	Then the last time had one of those / mine fall apart
63.	Mr. E.	I will have to bring in more kites to show you //
64.	Mr. E.	I have a lot of kites
65.	*unclear*	how many
66.	Mr. E.	I just have six
67. - 77.	NC	
78.	Mr. E.	Which direction is the wind blowing^
79.	Mr. E.	Let me draw a picture //
80.	Mr. E.	And I want people
81.	*multiple*	*overlapping talk*
82.	Mrs. C.	Don't call out / listen to Mr. E.
83.	Mr. E.	Here is a picture
84.	Mr. E.	I'm a great artist
85.	Mr. E.	Here's me / this is me
86.	Marquisha	that's a stick person
87.	Mr. E.	I said I was a great artist what do you want
88.	Mr. E.	There's my kite

line	Speaker	Utterance
89.	Mr. E.	Now / which direction is the wind blowing^
90.	*multiple*	*several students waving their hands*
91.	Mr. E.	I see that Kelvin has his hand up
92.	Mr. E.	Which direction is the wind blowing^
93.	Kelvin	this way
94.	Mr. E.	Which is this way^
95.	Mr. E.	Is it blowing this way^
96.	Mr. E.	*draws on board* is it blowing like this^
97.	Kelvin	its this way *gesturing*
98.	Darrel	naa /
99.	Darrel	its blowing that way
100.	Mr. E.	So I should have my arrow pointing over here^
101.	Darrel	yes
102.	*multiple*	*overlapping talk*
103.	Mr. E.	Thumbs up for people that agree
104.	Mr. E.	OK people that don't agree raise your hand and give a different idea//
105.	Mr. E.	Felicity
106.	Mr. E.	Oh you had a thumb up^
107.	Mr. E.	Anybody that disagrees^
108.	Mr. E.	OK So we all know that the wind is blowing that way
109.	*multiple*	*voicing agreement and disagreement*
110.	Mrs. C.	Raise your hand if you think it goes a different way
111.	Mr. E.	Lora
112.	Lora	The wind goes anyway it wants
113.	Mr. E.	But in this picture / in this situation / we all agree that the wind is going this way//
114.	*multiple*	*no we didn't*
115.	Mr. E.	Raise your hand if you don't agree//
116.	Mr. E.	Felicity
117.	Felicity	It goes this way *gestures opposite the direction of the arrow*
118.	Mr. E.	Felicity says
119.	Mr. E.	I'm going to draw it different

line	Speaker	Utterance
120.	Mr. E.	Felicity says the wind is going this way
121.	Mr. E.	no we didn't
122.	*multiple*	*overlapping talk*
123.	*multiple*	*overlapping talk (*it's coming that way / it's coming right on the back)
124.	*multiple*	*several students talking*
125.	Mr. E.	Hmm we're going to have to test this out

11)Light spreads – January 7, 2002

This discussion lasts 13 minutes, including 161 lines of transcript. Students completed a worksheet prior to the discussion designed to assess students' understandings of particular district objectives. Since use of worksheets was not a common practice in the classroom or in science, this distinguished this discussion.

At the beginning of the discussion I told the students that I knew that the worksheet was hard. I also explained that it was sometimes good to be challenged. I explained that we have not talked about how light moves or travels. Then I asked the students to describe how the light "gets from that light bulb to my eyes (line 3)."

Breanne was the first to respond. She repeated another student's ideas about wire inside the glass and light shooting from the wire (line 7). But she added description of the how the light "shoots [...] and it spreads (line 9)." I jumped in, asking her to clarify what she meant by spreads (line 10). The remainder of the discussion focused on describing how light spreads.

Breanne described the light spreading and connecting (line 23). In doing so, she restated, in a slightly different arrangement, all the prior claims about the

nature of light movement. I explained that we are still talking about spreading, and I wanted to know what they mean by 'spreading' (line 30). Breanne attempted a response with an example, talking about a specific light source in the classroom (lines 31-37). Annie wanted to join the conversation, but first asked me to repeat the question (line 46). I recapped the main points I interpreted in the discussion: spreading and connecting light (lines 47-50). Annie then described an analogy for spreading by talking about her arms outstretched (lines 51-54). Breanne jumped in, adding comments about light shooting from the wire in the bulb (lines 63-68).

Next, Isaac asked about 'how the light bulb spreads all round' (line 85). This led to a series of claims, examples, and analogies. Isaac, based on prompting from me, called on students to help him understand spreading. Breanne attempted to respond by offering and example of turning on a single light and it 'fill[ing] up some' of the room, but not all (104). At this point, it seemed to me that Isaac was not listening, so I called on him. He in turn asked me to explain what I thought the students were talking about with spreading (line 113). The selection ends here because the discussion focuses on me trying to explain using multiple analogies, Breanne's statement about light spreads. The remaining lines all focus on me explaining and developing analogies for the different theories that students posed earlier in the discussion.

This discussion included a lot of student talk, but only three students were talking. Those same three students experienced uptake from one another. However, the result was that Breanne solely developed the account, Annie

offered minor support, and Isaac asked questions. Breanne did introduce some human agency, but it was limited. Furthermore her thirty-eight utterances, of the one hundred five total utterances, were almost all repetitions of prior statements. Therefore this discussion on closer analysis had limited joint construction.

line	Speaker	Utterance
1.	Mr. E.	I want to talk about how the light gets from there to our eyes//
2.	Mr. E.	So there is light coming from that light bulb//
3.	Mr. E.	How did the light get from the light bulb to my eyes^
4.	Annie	*jumping in* uggh / look at it
5.	Multiple	*overlapping with Annie, unclear*
6.	Mr. E.	Breanne / did you *trails off*
7.	Breanne	Because there' s a wire inside the light bulb and it /
8.	Breanne	from the wire it shoots out the light bulb when you pull the string or turn the thing//
9.	Breanne	It shoots out from the light bulb and it spreads//
10.	Mr. E.	What do you mean it spreads^
11.	Mr. E.	Say more
12.	Unknown	*inaudible interruption*
13.	Mrs. C.	Just a minute let her say//
14.	Mr. E.	I have a feeling there are people that aren't listening to Breanne right now//
15.	Mr. E.	And that really worries me//
16.	Annie	To TaBreanne^
17.	Mr. E.	To / Breanne //
18.	Mr. E.	Listening / to / Breanne
19.	Mr. E.	Could we all give our attention to Breanne right now
20.	Annie	I can't see
21.	Mr. E.	when she explains what she means by the light spreads //
22.	Annie	I can't see
23.	Breanne	The light spreads from the wire inside of the / umm/ light bulbs//
24.	Breanne	and it connects//
25.	Breanne	But when you put [unclear]
26.	Annie	I can't see
27.	Breanne	*continuing*[unclear at first] light shoots from the wire and goes out through the glass of the light bulb//
28.	Breanne	And then it spreads//
29.	Mr. E.	We are still stuck with it spreads//

line	Speaker	Utterance
30.	Mr. E.	Can somebody help us / help me understand what this spreads^
31.	Breanne	light spreads because if you turn on one light its brighter in that area//
32.	Breanne	If you turn on like /
33.	Breanne	if you have three lit /
34.	Breanne	and you turn on all three of them /
35.	Breanne	then they spread and they connect together//
36.	Breanne	See that light bulb light is connecting to that one //
37.	Breanne	And that light is connecting to that one //
38.	Mr. E.	Can you call on somebody to speak next ^
39.	Breanne	*pointing* _____
40.	NC	
41.	Mr. E.	OK / you need to call on someone else//
42.	Mr. E.	If you want to speak you really need to raise your hand clearly//
43.	Mr. E.	If you do like this *gestures with hand hanging over head* its hard to know//
44.-45.	NC	
46.	Annie	What was the question that you asked^
47.	Mr. E.	Well one thing that Breanne said that I don't really understand for sure is that light spreads from the light bulb//
48.	Mr. E.	The other thing she said is that it comes together with other lights//
49.	Mr. E.	But I was just going to wait on that one because I didn't quite understand this spreading//
50.	Mr. E.	So there were people that thought they could help me understand the spreading idea//
51.	Annie	Ohh / I think what she means is sometimes /
52.	Annie	you know how we go like this^ *sticks arms out to the sides*
53.	Annie	that we are spreading our arms out//
54.	Annie	It means spreading around like this *gestures moving arms in a circle around her body*
55.	Mr. E.	Like all in a circle^
56.	Annie	No
57.	Mr. E.	Or / no / just in one direction^
58.	Annie	All around
59.	Breanne	It shoots from all on the side and the top it shoots out//
60.	Mr. E.	So like in a big ball^
61.	Breanne	yeah
62.	Mr. E.	OK

line	Speaker	Utterance
63.	Breanne	Except it goes farther//
64.	Breanne	Like / like some of it spreads faster than other /
65.	Breanne	some of it spreads closer /
66.	Breanne	but not like [unclear] a circle /
67.	Breanne	but like uneven edges /
68.	Breanne	they are kind of like uneven like zig zag / straight / and curly //
69.	Mrs. C.	It does all those different things^
70.	Breanne	*nodding* It can because when you turn it on some of it comes like / in the wires are lined when you want it it comes out and then /
71.	Breanne	*long pause* the umm / cord that's like when you pull it / and light come out from the cord //
72.	Breanne	The first half of it / the light / when you turn it off / is like the light is still//
73.	Breanne	When you turn it off [unclear] the light shoots in the wire //
74.	Breanne	It goes through the glass kind of / it like//
75.	Breanne	Electricity //
76.	Breanne	The wire past the glass / kind of through the glass /
77.	Breanne	and that / and then the water comes out the light or flashlight//
78.	Breanne	Except the flashlight has batteries//
79.	Mr. E.	OK //
80.	Mr. E.	Breanne we need to stop you and interrupt you because there were two people that I know, Isaac and Rodger, who hadn't had a chance to talk//
81.	Mr. E.	And then Brittany also wanted to say something and she / we didn't get to hear all of what she had to say either//
82.	Mr. E.	So do any of the three of you still want to talk^
83.	NC	
84.	Mr. E.	Isaac^
85.	Isaac	I don't understand how it / how the light bulb spreads all around
86.	NC	
87.	Mr. E.	Just a minute
88.	Mrs. C.	Wait just a second *motions to Breanne*
89.	Mr. E.	Was there anyone that feels like they could help Isaac understand this spreading all around idea^
90.	Mr. E.	Isaac / why don't you call on someone and see if they can help you understand that//
91.	Isaac	_____

line	Speaker	Utterance
92-94.	NC	She means when it spreads it goes all around the place//
95.	Mr. E.	Does that help^
96.	Mr. E.	Or do you need to ask someone else^
97.	Isaac	Ask someone else//
98.	Mr. E.	OK /keep raising your hand because we have got to help Isaac understand this//
99.	Mr. E.	*Toward Isaac* Call on someone you think can help you understand this
100.	Isaac	Breanne
101.	Breanne	*softly* The light comes
102.	Mr. E.	Speak really loud because its kind of loud over there and I can't hear you//
103.	Breanne	The light is / when it spreads it like /
104.	Breanne	When you turn on one light / it doesn't fill up the whole place but it does fill up some of it//
105.	Breanne	[unclear] Its like one of them / that light can't light the whole room//
106.	Mr. E.	*interrupting talking to Isaac who doesn't seem to listen to Breanne* Isaac are you listening to this^
107.	Mr. E.	does this help you^
108.	Isaac	umm / yes
109.	Mr. E.	What did she just say about the light^
110.	Isaac	I forgot
111.	Mr. E.	OK / lets try again //
112.	Mr. E.	I feel like there is a lot of squirming and not very much listening//
113.	Isaac	I / I'd like Mr. Enfield to say it because I am good at hearing him//
114.	Mr. E.	Ohh / OK / You want me to explain it^
115.	*Isaac*	*nods*
116.	Mr. E.	I think what they're saying //
117.	Mr. E.	Let me try to see if I *responding to Breanne who still wants to talk*
118.	Mr. E.	Imagine my fist is the light bulb //
119.	Mr. E.	And what people are saying is that everywhere around my fist /
120.	Mr. E.	each little spot that you can imagine/
121.	Mr. E.	there is a little bit of light coming out //
122.	Mr. E.	And it goes out in straight lines all the way around it in a big circle all the way around in all directions//
123.	Mr. E.	So it gets bigger
124.	Isaac	What do you mean about light beams^
125.	Mr. E.	Light beams / that's the

line	Speaker	Utterance
126.	NC	*jumping in* LIGHT BULBS light bulbs
127.	Mr. E.	Wait / _____
128.	Mr. E.	Isaac asked me to explain and so you're jumping in//
129.	Mr. E.	I'm imagining that the light is in straight lines//
130.	Mr. E.	That's the way I imagine it//
131.	Mr. E.	So it's like your finger //
132.	Mr. E.	If this was the light bulb / and little lines coming off of it / that's what I'm imagining//
133.	Isaac	Could it be like / you mean its
134.	Breanne	Except it spreads
135.	Mr. E.	It spreads in all directions//
136.	Isaac	So you mean like your fingers are the lines^
137.	NC	
138.	Mr. E.	Or like umm / has anybody ever seen a koosh ball^
139.	Mr. E.	Do you know what that is^
140.	Multiple	*Laughter*
141.	NC	
142.	Isaac	What is that^
143.	Mr. E.	I don't know if I have one still
144.	Mrs. C.	I might still have one
145.	Mr. E.	Like a pom-pom on your / like a little ball on your stocking cap//
146.	Mr. E.	Does anybody have one of those^
147.	Bobby	Yeah
148.	Rodger	Yeah
149.	*Multiple*	Ooh I got one
150.	Mr. E.	And the little fuzz sticks up in all different directions/ all around//
151.	*Multiple*	yeah / I've got one
152.	Isaac	You mean how it looks like
153.-154	NC	
155.	Mr. E.	Whoa / Whoa / we got a bunch of talking going on now//
156.	Mr. E.	You got a ball like that at daycare^
157.	Bobby	You can squeeze it
158.	Mr. E.	Where things stick straight out in all directions//
159.	Isaac	yeah I guess//
160.	Alexandro	It can be all different colors
161.	Alexandro	That's called a kooshie//

12) Light reflects – January 9, 2002

This selection lasted approximately 21 minutes, resulting in 254 lines of transcript. The selection included observations of spectra created when a prism was held above an overhead projector in a darkened room.

The initial 60 lines include students' utterances as they made observations of the spectra. This included primarily descriptions of observations and expressions about the images. Isaac theorized that a particular part made the rainbow (line 10). I asked students to explain what was happening to the light to make this happen (line 21). Brittany observed and speculated that the reason two spectra were produced was because there were two sides to the prism (line 23). Some student continued to describe observations later in the discussion. Breanne reported detailed observations of the spectra (line 142) during the discussion about reflection.

Once the classroom lights were turned on, I asked the class to explain "what does the prism do (line 65)?" Annie began saying, "the bright lights makes that thing make a rainbow (line 73)." After this Isaac jumped in saying, "its probably reflecting (76)." I asked what he meant by reflecting (line 78). The remainder of the discussion concerned explaining reflection. Isaac began to explain reflecting saying that it was like a line, making gestures to explain his idea (line 83). I attempted to clarify his idea by drawing a picture to represent the bouncing light on the board. Isaac and I shared the floor to explain the reflecting idea for a number of turns.

I invited other students to join the discussion to see if other people had ideas about bouncing light or light in the prism (line 132). Isaac jumped in saying that "it's like its going fast and bouncing fast (line 134)." Isaac added to the analogy saying it was like a ball bouncing (line 166), comparing light (line 174) to the ball and that it was the light reflecting. A non-consenting student asked Isaac a question. In the process of answering the question, Isaac decided that the ball analogy failed to account for two rainbows from one light source. Breanne joined this discussion, attempting to reconcile the ball analogy and account for two rainbows. However, her assertions become confusing because she mixed in human agency and multiple gestures.

There was no conclusion in this discussion to account for how light is refracted in a prism to produce spectra. This selection also had limited participation of students, with only five students speaking in the selection. In addition, only four students had their ideas receive uptake. Similar to the light spreads talk, this selection was dominated by one student, Isaac who took made twenty-six utterances and was taken up nineteen times. Breanne made a large number of utterances (thirty-eight) but received uptake only six times.

line	Speaker	Utterance
1.		*The class is looking at refracted light by a prism, lights are low and students are collected on the floor writing in their journals*
2.	Mr. E.	How does the rainbow get the rainbow get there and back behind it^
3.	Annie	Can you move your body^
4.	Mr. E.	If the light is going up there^
5.	Mr. E.	What do you say Brittany^
6.	NC	
7.	Mr. E.	OK /
8.	Mr. E.	*Repeated NC Student*

line	Speaker	Utterance
9.	Mr. E.	Isaac
10.	Isaac	Maybe it's because of the / the behind it is still part where it has the rainbow
11.	Mr. E.	The behind it is still part
12.	Isaac	I'm talking *comes up to point at the overhead (the light source)* I'm talking about this side *pointing*
13.	NC	
14.	Breanne	Its fading out
15.	Mr. E.	What about this side^
16.	NC	
17.	Isaac	I think that's the spot that's making the rainbow
18.	Mr. E.	What is that spot doing?
19.	*Breanne*	The rainbow is fading... bending up
20.	*Multiple*	*Overlapping talk*
21.	Mr. E.	What is happening to the light to make this happen^
22.	Mr. E.	Brittany
23.	Brittany	Cause the light shines from two different sides on the thingy
24.	*Multiple*	*Overlapping talk*
25.	Mr. E.	You're saying from two different sides of this^
26.	Mr. E.	*points at prism* on this side and this side^ OK
27.	Mr. E.	That's probably a pretty important observation//
28.	Isaac	I can see two rainbows
29.	Mr. E.	There's one there and one there *points*
30.	Mr. E.	What else do people see^
31.	Mr. E.	Umm / Brittany
32.	NC	
33.	Mr. E.	Yea there is a rainbow straight above
34.	Alexandro	There is bigger rainbow up there
35.	Mr. E.	Umm / Shanice
36.	NC	
37.	NC	
38.		*Mr.E. adds books to the overhead in order to make a slit of light. Several students start expressing oohs and aahs.*
39.	Annie	*Yelling out* Ahh sweet
40.	Brittany	Look at that one behind you Mr. E.
41.	Mr. E.	Huh^
42.	Brittany	Look behind you Mr. E.
43.	Annie	*Yelling* look behind you
44.	Mrs. C.	Mr. E. I think you want them thinking about just this one
45.	Mr. E.	I want you thinking just about the one over there //

line	Speaker	Utterance
46.	Mr. E.	The one behind is OK too //
47.	Jordan	That one is skinny
48.	Mr. E.	The one straight above
49.	Mr. E.	There's not much light /
50.	Mr. E.	see how if I take this one away /
51.	Mr. E.	there is just a slit of light coming out straight above//
52.	Mr. E.	There is just a little bit of light coming out //
53.	Mr. E.	Now when I put the prism up
54.	*Multiple*	*Overlapping voices*
55.	NC	
56.	*Multiple*	*Overlapping voices*
57.		*Students writing observations. Mr. E. then turns the lights on*
58.	Annie	There still is one
59.		*Mr.E. turns off the overhead projector*
60.	Alexandro	Now there's not
61.	Mrs. C.	I noticed a lot of kids were writing Mr. E.
62.	Mrs. C.	They are kind of excited about this
63.		*Mr.E. comes and sits on the floor with students*
64.	Mr. E.	So what do you think is happening^
65.	Mr. E.	What does that prism do^
66.	Mr. E.	What's the prism do^
67.	NC	
68.	Mr. E.	*Repeated NC student idea*
69.	Mr. E.	_____
70.	NC	
71.	Mr. E.	*Repeated NC student idea*
72.	Annie	You know what ^
73.	Annie	The bright lights makes that / umm / that thing umm/ make a rainbow
74.	Mr. E.	OK /
75.	Mr. E.	Isaac
76.	Isaac	It's probably reflecting
77.	Mr. E.	It's probably reflecting /
78.	Mr. E.	what do you mean by reflecting^
79.	Isaac	Its like
80.	Mr. E.	Hang on Isaac / just wait a minute
81.	Mr. E.	I want to make sure everybody is listening because Isaac is trying to tell us something important about reflecting and there are some kids that are squirming //
82.	Mr. E.	Try again *to Isaac* I'm sorry

line	Speaker	Utterance
83.	Isaac	Its like / Its like / Its like / Its like a line and if it is touching that it will just go back
84.	Isaac	See like reflecting like ding ding *pointing with his hands to show the movement of the light* coming back
85.	Annie	I don't understand
86.	Isaac	it's umm reversing
87.	Mr. E.	OK
88.	Mr. E.	so I'm going to draw what I think Isaac is talking about
89.	Mr. E.	and he's going to tell me if its right
90.	Mr. E.	He's saying the light is coming like this *drawing on board*
91.	Mr. E.	and it hits /
92.	Mr. E.	I had the prism like this /
93.	Mr. E.	and it goes up in here it reverses that way //
94.	Mr. E.	Is that what you're talking about^
95.	Isaac	*Walking to board* no I am talking about like this
96.	Isaac	*Takes pen and begins drawing on board*
97.	Mr. E.	Can you reach up there ^ its kind of far //
98.	Isaac	It's doing this
99.	Annie	I still don't understand
100.	NC	
101.	Mrs. C.	Well it's a slight be of difference
102.	Mr. E.	There's some difference
103.	Mrs. C.	Between his idea and Mr. E.'s
104.	Annie	I still don't understand
105.	Mr. E.	Hang on /
106.	Mr. E.	let me make sure everybody understands
107.	Annie	I don't
108.	Annie	I don't understand a bit
109.	Mr. E.	Imagine / that we're looking at it this way // *holds the prism up showing the end*
110.	Mr. E.	This is what we are talking about /
111.	Mr. E.	we were looking at the end
112.	Mr. E.	And actually lets move it down here to this paper so we got some big drawing here//
113.	Mr. E.	And so this is what the end of it looks like
114.	NC	
115.	Mr. E.	It looks like a big triangle like that //
116.	Mr. E.	And Isaac says that the light comes here //
117.	Mr. E.	And can I draw it off that way Isaac^
118.	Mr. E.	is it OK if it reflects that way^
119.	Isaac	mm-hmm
120.	Mr. E.	And goes off this way
121.	Mr. E.	So this is the light /

line	Speaker	Utterance
122.	Mr. E.	I'll put an arrow on it
123.	Mr. E.	and I said
124.	Annie	Ohh see that looks different
125.	Mr. E.	I said that the light was coming this way and going through and when I hits this side it bounces this way
126.	Mr. E.	Can it do both things^
127.	Multiple	yes
128.	Annie	So *turning to Isaac*
129.	Isaac	You don't have to be so mean about it Annie
130.	Annie	I wasn't
131.		*Some unclear overlapping talk*
132.	Mr. E.	What other ideas do people have about the way the light is going through the prism or in the prism^ or bouncing off^
133.	Mr. E.	Does anybody else have a different idea^
134.	Isaac	Its like its going fast and bouncing fast because fast makes it reflect
135.	Mr. E.	Isaac says fast is important /
136.	Mr. E.	I'm going to put that /
137.	Mr. E.	I'll put fast right here //
138.	Mr. E.	Breanne what did you want to say^
139.	Breanne	If / the / when you / when the rainbow was up on the ceiling
140.	Mr. E.	Uhh-huh
141.	Annie	I died
142.	Mr. E.	Annie let Breanne talk please
143.	Breanne	It / umm / when the rainbow was up on the ceiling it kind of like umm / changed different colors like from
144.	Breanne	Like when it was orange blue and purple and green / the orange turned in to red or off-white
145.	Mr. E.	They turned into different colors^
146.	Breanne	And plus one was like // uhh // kind of like the color of the door but except a little bit lighter //
147.	Mr. E.	Pam are you OK^ OK you look like you didn't feel good
148.	Breanne	But except one that was over there / it was square / except there was light like that color *pointing to the big paper at the front*
149.	Mr. E.	Light like what color^
150.	Breanne	*Coming up to point directly at the prism* This its kind of like this
151.	Mr. E.	Its clear^ is that what you mean
152.	Breanne	Yup
153.	Breanne	but except those were lighter

line	Speaker	Utterance
154.	Mr. E.	OK
155.	Breanne	Yea but there was a little bit of white in it
156.	Mr. E.	OK Annie
157.		*Announcement*
158.	Mr. E.	*Speaking to Isaac who is walking to the front* Isaac I need you to sit still because Annie was waiting to talk //
159.	Mr. E.	*Annie moves the microphone* Thank you Annie / what were you wanting to say^
160.	Annie	It wasn't actually white / like this / it was pineapple clear
161.	Mr. E.	Pineapple clear^
162.	Annie	Mm-hmm
163.	Mr. E.	OK / Pineapple clear /
164.	Mr. E.	Now Isaac what did you want to say ^
165.	Mr. E.	watch out when you walk up here
166.	Isaac	Its like it's a ball *holds his a hand up*
167.	Isaac	here's the wall *holds other had up* and this is a ball
168.	Mr. E.	What's the ball^
169.	Mr. E.	Turn around and tell them
170.	Isaac	Here's the wall *gestures with left hand held straight up* here's the ball *holds right hand in a fist opposite his left hand* and its like mmm *moves right hand toward left and bounces off left hand making noises to represent movement* mmm / mmm
171.	Mr. E.	What's the ball^
172.	Isaac	The ball^ its my hand *emphatically*
173.	Mr. E.	No but what do you thi- / what are you saying the ball is when you are talking about this
174.	Isaac	THE LIGHT *very emphatic*
175.	Mr. E.	The light is like a ball // Is that what you are saying^
176.	Isaac	yea
177.	NC	
178.	Isaac	*Response to NC student*
179.	Multiple	*Lots of overlapping voices*
180.	Mr. E.	Do people understand what Isaac is saying^
181.	Multiple	*Simultaneous* no
182.	Mr. E.	So why don't you ask him questions
183.	NC	
184.	Mr. E.	And try to clarify //
185.	Mr. E.	Isaac can you call on some people to ask you questions because I think you have an interesting idea that they need to understand
186.	Isaac	_____

line	Speaker	Utterance
187.	NC	
188.	Isaac	I can't actually hear well *means he doesn't understand*
189.	Mr. E.	Well just a minute /
190.	Mr. E.	I am listening to Darquise because I think I understand his question
191.	Mr. E.	*Talking to Isaac* stay right here /
192.	Mr. E.	do you want to sit here^ *offers him his seat Isaac accepts*
193.-198	Mr. E.	*Repeats NC student question*
199.	Isaac	hmm
200.	Breanne	I think I know
201.	Mr. E.	Just a minute let's let Isaac have a chance and then
202.	Annie	I don't understand
203.	Isaac	*Picking up the prism* it bounces off this
204.	Mr. E.	Uhh-huh
205.	Isaac	*Pointing* then it will hit like the ceiling or something
206.	Mr. E.	right
207.	Isaac	So I guess it will only hit one direction
208.	Mr. E.	So you are saying there could only be one if it's a ball / is that right ^
209.	Isaac	I will call it a light now
210.	Mr. E.	You'll call it a light now / OK
211.	Mr. E.	But that ball /
212.	Mr. E.	So _____'s / what he noticed
213.	Mr. E.	this is important /
214.	Mr. E.	hang on /
215.	Mr. E.	everybody catch up here //
216.	Mr. E.	This is really important / because what _____ did is _____ said I noticed something different that what Isaac was noticing //
217.	Mr. E.	And he was trying to get Isaac to explain his evidence too / he saw two rainbows
218.	Isaac	But I couldn't understand / because he doesn't give / I can only hear a little louder voices
219.	Mr. E.	*Talking to Isaac* Well I was trying to help him explain
220.	Mr. E.	Breanne thought she could explain your ball idea of bouncing and still work about the two rainbows //
221.	Mr. E.	Can you tell us that^
222.	Annie	I don't under-
223.	Breanne	*Comes to the area where Isaac and Mr. E. are sitting then picks up prism* the light went kind of like heading that way because when you put it /
224.	Breanne	when you put that thing down /

line	Speaker	Utterance
225.	Breanne	the light was kind of like heading that way and umm
226.	Mr. E.	*Interrupting* can you turn around and show other people because I know what you are talking about / but I don't think they do
227.	Breanne	*Turns around to the group holding the prism and pointing throughout* the light was facing this way and when it was facing this way it went on one of these sides /
228.	Breanne	I don't know which one /
229.	Breanne	but on one of these sides / and when it was on it /
230.	Breanne	it made like a umm // like a rainbow
231.	Breanne	And then when it like it hit this the light hit that and then it /
232.	Breanne	but except it was going like this except its going to hitted it /
233.	Breanne	when it comes back off it went /
234.	Breanne	it hit and then it went up and it made two
235.	Breanne	and from that shadow up there and they //
236.	Breanne	from that shadow up there it made umm rainbows /
237.	Breanne	two rainbows /
238.	Breanne	when he was turning it / it made two rainbows
239.	Mr. E.	*Taking the prism* so you're saying that
240.	Mr. E.	*responding to Isaac who comes to take the prism* hang on Isaac I want to see if I understand
241.	Isaac	I understand
242.	Mr. E.	*To Isaac* I want to see if I understand / OK
243.	Mr. E.	You're saying that when it was like this Breanne it came up and it could go out this way or this way *gesturing*
244.	Breanne	Yea
245.	Mr. E.	OK
246.	Breanne	Except it went / you had *turns the prism in Mr. E's hand*
247.	Mr. E.	Lets hold it like this / and the light is coming here
248.	Breanne	The light was like / you had it way down
249.	Mr. E.	No I had it like this //
250.	Breanne	OK /
251.	Breanne	when you had light that was like facing that way *gesturing again* it started doing like this /
252.	Breanne	like hitting /
253.	Breanne	and it went off an up and cause this thing
254.	Breanne	It kinds of like make a rainbow and it bends like the rainbow / like a real rainbow

13)What is a seed? May 13, 2002

This selection lasted almost 15 minutes, yielding 237 lines of transcript. It was part of a lengthy discussion about plants and preceded the selection, Seeds in a Flower (see below). This discussion came at a point in the year when I attempted to have students moderate the discussion. Students had some role in managing turns. I initiated the discussion, asking "what is a seed (line 1)?"

Annie asserted that, "It's something that grows into a plant (line 9)." Isaac repeated this idea (line26), but altered the statement to be a relationship rather than a model of growth. Breanne added to this line of the account (lines 129-132) describing stages in plant growth. Annie, building on Rodger and Erin, modified their ideas to revoice their claims avoiding human agency, "A plant seed, a seed needs water, light, and umm dirt (line 140)."

After several turns from non-consenting students, Rodger entered the discussion and described planting a seed (lines 104-107). Rodger's contributions focused on the things a human agent needed to do when planting seeds. Erin repeated many of Rodger's ideas about human agency in planting seeds (lines 136-138). Brittany asked Erin about her statement that "all seeds grow into flowers (line 146)," which was a statement made by Rodger, Annie, and Breanne. Rodger asked this same question to Annie (line 201). Annie responded to this with another account of human agency that if you plant a tree seed it grows into a tree (line 205).

I revisited my interpretation of the general ideas that seeds grow into plants (line 159) and then asked the class where seeds come from (line 168).

Isaac responded that seeds come from nature (line 171). Beverly added that seeds grow on trees (line 179) and then fall (line 180). Annie added to this to include how fruit comes from trees and that there are seeds in fruit (line 193). Picking up on her human agency description, Annie shifted to explain a complete life cycle of a fruit bearing tree (line 213-218). But when I asked her where seeds come from, she responded "stores sometimes (line 234).

The first portion of this discussion seemed to resolve the point that seeds were things that grow into plants. Furthermore there was little debate that there were certain things seeds needed. However, students were less sure about my question, "where do seeds come from?" This uncertainty was carried into the next selection. There were two points to mention. First there was significant number of references to human agency. Second, eight students actively participated and of these six received uptake.

line	Speaker	Utterance
1.	Mr. E.	What is a seed^
2.	Mr. E.	Let's start with what is a seed^
3.	Mr. E.	And so remember that we are going to call /
4.	Mr. E.	we're going to call on people /
5.	Mr. E.	like I'll call on Annie and Annie will call on the next person//
6.	Mr. E.	So what is a seed^
7.	Annie	umm
8.	Mr. E.	Annie
9.	Annie	It's something that grows into a plant
10.	Mr. E.	OK *opens journal to make notes*
11.	Annie	Isaac
12.	NC	
13.	Isaac	A seed is like something that
14.	Mr. E.	Umm / I'll put mine away OK^
15.	Mr. E.	How's that / is that fair^
16.	Rodger	*jumping in* NO
17.	NC	
18.	Rodger	I want to write

line	Speaker	Utterance
19.	Mrs. C.	Let's just talk first
20.	Mr. E.	Who did you call on Annie^
21.	Isaac	me
22.	Mr. E.	I was distracted
23.	Annie	Isaac
24.	Mr. E.	What did you say Isaac^
25.	Isaac	A seed is like / is s... / is something /
26.	Isaac	is something that before it its' a plant /
27.	Isaac	like it's a flower or a like tree
28.	Isaac	it starts out as a seed
29.	Isaac	Darquise
30.-33	NC	
34.	Bobby	What did he say^
35.	Mr. E.	Ask him a question
36.	Rodger	Umm Darquise *then raises his hand*
37.	Mr. E.	*several students with hands raised* Are these questions for Darquise or more statements^
38.	Rodger	For Darquise *points at Darquise*
39.	Mr. E.	OK
40.	Mr. E.	Darquise there are some people that have questions for you so you need to ask them
41.	Bobby	Look at Breanne
42.	Mr. E.	So you need to ask those people that have questions first
43.	Mr. E.	I heard Bobby say one but he didn't ask it
44.	NC	
45.	NC	
46.-47	NC	
48.	Mr. E.	Is there more questions for _____^
49.	Rodger	Umm/ _____ what do you mean like
50.	NC	
51.	Rodger	wait / wait / wait
52.	Rodger	This what you said the first time
53.	Rodger	Umm / you had said first they put it inside the ground
54.	Rodger	yeah the ground
55.	Rodger	then you said feed the seed
56.	Rodger	and yeah that is feed the seed
57.	Mr. E.	Did you say feed the seed Darquisie^
58.	NC	
59.	Mr. E.	Maybe you said something that sounded like feed the seed

line	Speaker	Utterance
60.	Bobby	I heard feed the seed
61.	NC	
62.	NC	
63.	Mr. E.	ohh pour the seeds in the ground
64.	Bobby	you got to water them
65.	Mr. E.	and then water the seeds
66.	Rodger	pour the seeds in the ground
67.	Bobby	How you going to pour the seeds in the ground^
68.	NC	
69.	Rodger	yeah
70.	*multiple*	*overlapping*
71.	Jordan	Like dumping them out of the bag
72.	Rodger	Ohh
73.	Bobby	I thought he was talking about ....
74.	Mr. E.	Erin do you have a question for _____^
75.	Annie	I do
76.	Mr. E.	Let's try to wrap up the questions for Darquise because there are other people that have things they want to say
77.	NC	
78.	Annie	Umm / plants / seeds /
79.	Annie	you don't pour them you plant them
80.	Annie	not pour
81.	Mr. E.	Hang on
82.	Mr. E.	Everybody put your hands down first
83.	Rodger	Pour them out of the bag Annie
84.	Mr. E.	OK
85.	Mr. E.	We clarified that what Darquise was talking about was pouring the seeds//
86.	Mr. E.	If you have a big bag of seeds /
87.	Mr. E.	you can actually pour them
88.	Mr. E.	just like you pour water
89.	Mr. E.	because little bits of seeds will go out //
90.	Mr. E.	But Annie wanted you to say plant them in the ground//
91.	Mr. E.	But one thing that we are having a problem with is that people need to ask questions to clarify what somebody says
92.	Mr. E.	So you could have asked
93.	Mr. E.	What do you mean by pour the seeds
94.	Mr. E.	And that is what we were having this discussion about
95.	Mr. E.	So that will help us a little bit
96.	Mr. E.	Let's move on to let other people talk / OK

line	Speaker	Utterance
97.	Mr. E.	So Darquise could you call on someone else^
98.	Annie	It's me
99.	Mr. E.	No you asked a question for Darquise
100.	NC	
101.	Rodger	Umm
102.	Rodger	well
103.	Rodger	I got like some real big seeds
104.	Rodger	And if you dig a small hole
105.	Rodger	that won't work for it
106.	Rodger	if it is a real big seed
107.	Rodger	you got to dig the hole real deep so it will grow good
108.	Mr. E.	I noticed some people were really listening carefully to what Rodger had to say
109.	Mr. E.	and some people were not doing such a good job of carefully listening//
110.	Mr. E.	Rodger you need to call on somebody OK
111.	Mr. E.	There are a couple of people that have been waiting a long time
112.	Rodger	Umm / Isaac
113.	Bobby	you got your hand up
114.	Rodger	Ohh / _____ then
115.-121	NC	
122.	Mr. E.	OK Call on somebody that hasn't had a chance yet
123.	Isaac	I didn't hear what Rodger said
124.	Mr. E.	Rodger said
125.	Jordan	Ohh my gosh
126.	Mr. E.	Hang on just a minute
127.	Mr. E.	*to Isaac* Let's let somebody else
128.	Isaac	Breanne
129.	Breanne	A seed even grows into a plant
130.	Breanne	First it has leaves
131.	Breanne	and the green little plant comes from the seed but it also comes from the stem too
132.	Mr. E.	OK a couple more people are still waiting
133.	*multiple*	*overlapping talk*
134.	Mr. E.	quickly
135.	Breanne	Erin
136.	Erin	First you plant the seed
137.	Erin	and when you give a seed water it grows into a plant
138.	Erin	and you keep on watering it and then it grows into a flower
139.	Erin	Annie

line	Speaker	Utterance
140.	Annie	A plant seed / a seed needs water / light / and umm dirt
141.	Mr. E.	OK now we are talking about the things a seed needs
142.	Mr. E.	cause some people are waiting to talk
143.	Annie	Brittany
144.	Brittany	I have a question for Erin
145.	Brittany	I mean I have a comment for Erin
146.	Brittany	not all seeds grow into flowers
147.	Erin	I know
148.		*some whispering*
149.	Erin	flowers and plants and other kind of stuff
150.	Mr. E.	Do you agree with that still^
151.	Mr. E.	do you want to call on somebody else^
152.	Brittany	Brittany
153.-157	NC	
158.	Mr. E.	Me^
159.	Mr. E.	So what I hear is that it seems like everybody seems to agree that a seed grows into a plant
160.	*multiple*	*multiple overlapping speech, some agreement*
161.	Mr. E.	Wait
162.	Mrs. C.	One at a time
163.	Mr. E.	I'm talking
164.	Mr. E.	a plant or tree or a flower or something like that
165.	Mr. E.	everybody seems to agree that a seed will grow into those things
166.	Mr. E.	just wait a minute
167.	Mr. E.	I'll let you ask questions
168.	Mr. E.	But what I want to know is where the seeds come from
169.	Mr. E.	Cause that's sort of confusing to me
170.	Mr. E.	Isaac / where do seeds come from?
171.	Isaac	Nature
172.	Mr. E.	But where in nature^
173.	Mr. E.	I need something a little better than just nature
174.	Isaac	Now I'm getting confused
175.	Isaac	Beverly
176.	Mr. E.	OK
177.	Mrs. C.	what did you say Isaac^
178.	Mr. E.	He said nature
179.	Beverly	They grow on kinds of trees
180.	Beverly	and then fall
181.	Beverly	and sometimes they fall on the dirt

line	Speaker	Utterance
182.	Mr. E.	Keep talking / let's let other people talk
183.	Mr. E.	see if I can get sorted out
184.	Mr. E.	Beverly you need to call on somebody else//
185.	Beverly	Annie
186.	Mr. E.	Rodger is your hand up^
187.	Mr. E.	Well you need to scoot out so she can see knows that
188.	Mr. E.	It looks like you are running your hand
189.	Annie	Trees have *audio glitches*
190.	Annie	If you got a tree seed and you want to grow it
191.	Annie	and that tree grows seeds
192.	Annie	and umm and it
193.	Annie	they get to little seeds and sometimes those little seeds grow into food
194.	Annie	and the food drops and some of the seeds come out
195.	Annie	plant another tree
196.	Annie	Brittany
197.	NC	
198.	Rodger	Umm not all seeds
199.	Bobby	*jumping in* grow
200.	Rodger	Annie / I got a question for you
201.	Rodger	Like you said how would a all seeds grow into a umm flower
202.	Rodger	That's what you said
203.	Annie	huh-uhh
204.	Annie	Here's what I said
205.	Annie	If you have a umm tree seed and you plant it and it grows and if has
206.	Annie	some trees have
207.	Rodger	I don't get it
208.	Annie	then they grow little seeds on them
209.	Annie	and then they grow food
210.	Annie	and sometimes the food falls off
211.	Annie	and it the seed
212.	NC	
213.	Annie	the seed it will fall off
214.	Annie	and food will fall down they might drop
215.	Annie	and then they fall out of the fruit
216.	Annie	and it will grow into a new tree
217.	Annie	and it will start all over again
218.	Annie	like a life cycle
219.		*several people including Mr. E. have hands raised. Many students whisper, Mr. E.*

line	Speaker	Utterance
220.	Mr. E.	Anybody / he can call on anybody
221.	Mr. E.	Darquise is your hand up^
222.	Mr. E.	You need to put it up to its clear
223.	Mr. E.	and Beverly's hand is up too
224.	Mr. E.	Me
225.	Mr. E.	What I thought Rodger was saying was that it sounds like you are saying Annie that all seeds come from trees//
226.	Mr. E.	Is that what you mean^
227.	Annie	I just mean some seeds
228.	Mr. E.	Some seeds come from trees
229.	Mr. E.	So where does ....
230.	Rodger	*jumping in* Like what kind of
231.	Mr. E.	Well maybe we don't need to know what kinds//
232.	Mr. E.	Like where do other seed come from^
233.	Mr. E.	If not all of them come from trees where do other ones come from ^
234.	Annie	Stores sometimes
235.	Annie	umm / I don't know what they come from
236.	Annie	I just / I don't know what they come from
237.	Mr. E.	OK

14) Seeds in a flower – May 13, 2002 – *Focal Discussion Two*

This selection lasted about 13 minutes, resulting in 236 lines of transcript. The discussion was selected out of a longer talk about plants. The discussion began when I asked one student to draw a picture of the claim her earlier assertion that there are seeds in sunflowers. She drew this on chart paper so that everyone could see. After the drawing was complete, Breanne (line 45) asked "how can there be seeds in a sunflower?" This question remained the main topic of discussion for the following 10-11 minutes of discussion.

Several students attempted to answer Breanne's question. However, Breanne and one other student were not satisfied with the students' answers. Breanne's assertion was that seeds and flowers are different, but interdependent

objects that exist simultaneously throughout the life of a plant. She started with "the sunflower grows" (line 34), which led to her question. Later she added that the seed was underground and responsible for plant growth (lines 53, 66, 68, 75, and 203), which suggests that the seed cannot be in the flower (lines 46 and 77). She claimed that the seed is in the ground and "that's how the flower grows (line 76)." Breanne never included human agency in her description of seeds.

Brittany described that seeds were in a flower so it could, "grow up out of there (line 91)." This explanation followed a structure-function idea. She thought the seed served a particular function, plant propagation. She summed this up saying, "It's up there so when the wind blows some of the seeds are down and you can grow another seed (line 92)." So she focused on the lifecycle of a flowering plant. Her explanation does not account for how the flower produced the seed, but this did not seem to be a problem for her. It was especially interesting in her account that she introduced human agency in line 92, which was not included in her earlier utterances. This suggests that she thought something is required to complete the process.

One explanation, which received little attention and limited uptake, was that "bees make seeds and put it [seeds] in flowers (line109)." Students did not take up this explanation until the last minutes of the discussion. Furthermore, my reaction (line 113) to the idea did not encourage others to discuss the idea. It is notable though because Rodger, who made repeated attempts to join the conversation, tried to challenge this assertion (line 236). However this challenge was limited to two turns in the entire discussion.

Annie offered another explanation built off prior comments from non-consenting students. This was that seeds, once they sprout roots and grow a stem, go up the stem, break apart in the flower and make new seeds (line 156-159). This explanation came late in the discussion, however when given the chance, Breanne revisited this claim stating that she "want(s) to know how the seed can go up [the stem]" (line 233).

Just as in preceding discussions, there was no resolution to the question and students did no end with a single account. This discussion was considerably improved in terms of participation, including eleven students. But students' uptake of ideas was not as good. There were only seventeen uptakes in 137 analyzable utterances, twelve of which focused on Breanne's claims. Furthermore, only four students' utterances were taken up.

Line	Speaker	Utterance
1.	Mr. E.	What is a seed^
2.	Mr. E.	Let's start with what is a seed^
3.	Mr. E.	And so remember that we are going to call /
4.	Mr. E.	we're going to call on people /
5.	Mr. E.	like I'll call on Annie and Annie will call on the next person//
6.	Mr. E.	So what is a seed^
7.	Annie	umm
8.	Mr. E.	Annie
9.	Annie	It's something that grows into a plant
10.	Mr. E.	OK *opens journal to make notes*
11.	Annie	Isaac
12.	NC	[*requests to use science journals*]
13.	Isaac	A seed is like something that
14.	Mr. E.	Umm / I'll put mine away OK^
15.	Mr. E.	How's that / is that fair^
16.	Rodger	*jumping in* NO
17.	NC	
18.	Rodger	I want to write
19.	Mrs. C.	Let's just talk first
20.	Mr. E.	Who did you call on Annie^

21.	Isaac	me
22.	Mr. E.	I was distracted
23.	Annie	Isaac
24.	Mr. E.	What did you say Isaac^
25.	Isaac	A seed is like / is s- / is something /
26.	Isaac	is something that before it its' a plant /
27.	Isaac	like it's a flower or a like tree
28.	Isaac	it starts out as a seed
29. - 100.	NC	
101.	Rodger	Umm
102.	Rodger	well
103.	Rodger	I got like some real big seeds
104.	Rodger	And if you dig a small hole
105.	Rodger	that won't work for it
106.	Rodger	if it is a real big seed
107.	Rodger	you got to dig the hole real deep so it will grow good
108.	Mr. E.	I noticed some people were really listening carefully to what Rodger had to say
109.	Mr. E.	and some people were not doing such a good job of carefully listening//
110.	Mr. E.	Rodger you need to call on somebody OK
111.	Mr. E.	There are a couple of people that have been waiting a long time
112.	Rodger	Umm / Isaac
113.	Bobby	you got your hand up^
114. - 127.	NC	
128.	Isaac	Breanne
129.	Breanne	A seed even grows into a plant
130.	Breanne	First it has leaves
131.	Breanne	and the green little plant comes from the seed but it also comes from the stem too
132.	Mr. E.	OK a couple more people are still waiting
133.	*multiple*	*overlapping talk*
134.	Mr. E.	quickly
135.	Breanne	Erin
136.	Erin	First you plant the seed
137.	Erin	and when you give a seed water it grows into a plant
138.	Erin	and you keep on watering it and then it grows into a flower
139.	Erin	Annie
140.	Annie	A plant seed / a seed needs water / light / and umm dirt
141.	Mr. E.	OK now we are talking about the things a seed needs
142.	Mr. E.	cause some people are waiting to talk

143.	Annie	Brittany
144.	Brittany	I have a question for Erin
145.	Brittany	I mean I have a comment for Erin
146.	Brittany	not all seeds grow into flowers
147.	Erin	I know
148.		*some whispering*
149.	Erin	flowers and plants and other kind of stuff
150.	Mr. E.	Do you agree with that still^
151.	Mr. E.	do you want to call on somebody else^
152.	Brittany	NC
153. - 157.	NC	
158.	Mr. E.	So what I hear is that it seems like everybody seems to agree that a seed grows into a plant
159.	*multiple*	*multiple overlapping speech, some agreement*
160.	Mr. E.	Wait
161.	Mrs. C.	One at a time
162.	Mr. E.	I'm talking
163.	Mr. E.	a plant or tree or a flower or something like that
164.	Mr. E.	everybody seems to agree that a seed will grow into those things
165.	Mr. E.	just wait a minute
166.	Mr. E.	I'll let you ask questions
167.	Mr. E.	But what I want to know is where the seeds come from
168.	Mr. E.	Cause that's sort of confusing to me
169.	Mr. E.	Isaac / where do seeds come from?
170.	Isaac	Nature
171.	Mr. E.	But where in nature^
172.	Mr. E.	I need something a little better than just nature
173.	Isaac	Now I'm getting confused
174.	Isaac	Beverly
175.	Mr. E.	OK
176.	Mrs. C.	what did you say Isaac^
177.	Mr. E.	He said nature
178.	Beverly	They grow on kinds of trees
179.	Beverly	and then fall
180.	Beverly	and sometimes they fall on the dirt
181.	Mr. E.	Keep talking / let's let other people talk
182.	Mr. E.	see if I can get sorted out
183.	Mr. E.	Beverly you need to call on somebody else//
184.	Beverly	Annie
185.	Mr. E.	Rodger is your hand up^
186.	Mr. E.	Well you need to scoot out so she can see knows that
187.	Mr. E.	It looks like you are running your hand

188.	Annie	Trees have *audio glitches*
189.	Annie	If you got a tree seed and you want to grow it
190.	Annie	and that tree grows seeds
191.	Annie	and umm and it
192.	Annie	they get to little seeds and sometimes those little seeds grow into food
193.	Annie	and the food drops and some of the seeds come out
194.	Annie	plant another tree
195.	Annie	NC
196.	NC	
197.	Rodger	Umm not all seeds
198.	Bobby	*jumping in* grow
199.	Rodger	Annie / I got a question for you
200.	Rodger	Like you said how would a all seeds grow into a umm flower
201.	Rodger	That's what you said
202.	Annie	huh-uhh
203.	Annie	Here's what I said
204.	Annie	If you have a umm tree seed and you plant it and it grows and if has
205.	Annie	some trees have
206.	Rodger	I don't get it
207.	Annie	then they grow little seeds on them
208.	Annie	and then they grow food
209.	Annie	and sometimes the food falls off
210.	Annie	and it the seed
211.	NC	
212.	Annie	the seed it will fall off
213.	Annie	and food will fall down they might drop
214.	Annie	and then they fall out of the fruit
215.	Annie	and it will grow into a new tree
216.	Annie	and it will start all over again
217.	Annie	like a life cycle
218.		*several people including Mr. E. have hands raised. Many students whisper, Mr. E.*
219.	Mr. E.	Anybody / he can call on anybody
220.	Mr. E.	NC
221.	Mr. E.	You need to put it up to its clear
222.	Mr. E.	and Beverly's hand is up too
223.	Mr. E.	Me
224.	Mr. E.	What I thought Rodger was saying was that it sounds like you are saying Annie that all seeds come from trees//
225.	Mr. E.	Is that what you mean^
226.	Annie	I just mean some seeds
227.	Mr. E.	Some seeds come from trees

228.	Mr. E.	So where does ....
229.	Rodger	*jumping in* Like what kind of
230.	Mr. E.	Well maybe we don't need to know what kinds//
231.	Mr. E.	Like where do other seed come from^
232.	Mr. E.	If not all of them come from trees where do other ones come from ^
233.	Annie	Stores sometimes
234.	Annie	umm / I don't know what they come from
235.	Annie	I just / I don't know what they come from
236.	Mr. E.	OK

Appendix B

Coding Schemes Used in Analysis

Each student utterance was coded for several different attributes. These attributes reflect the theoretical and analytic framework described in Chapter Two. It is important to note that these codes were developed through a constant comparative method (Glaser & Strauss, 1967), reflecting a emic perspective as arising from the data rather than being imposed on the data.

Participation: How can students' participation in joint construction of accounts be described in terms of claims and accounts?

Coding for participation involved two descriptions of students' utterances. The first looked at the nature of the utterance to describe whether the utterance was a new claim or whether it was a shared utterance. If the utterance was shared, the second coding identified the lines that the speaker referred to. In order to consider the different ways that students might share utterance, coding for the nature of utterances included the following codes. These codes were useful in determining percentages of participation, but were not included in the methods described in Chapter Three or the findings described in Chapter Four.

1. Revoice – involves repeating an utterance making small changes.
2. Repeat – involves repeating exactly an utterance of a prior speaker.
3. Re-state – involves repeating an utterance giving credit to the person who initially made the utterance
4. Combine – means connecting two or more prior utterances.
5. Extension – involves adding to a prior utterance.

Language: How does the language students use support joint construction of accounts and also reveal something about the nature of the accounts that students construct?

Coding for language focused on describing the semantic relationships and thematic patterns students used in discussions to communicate ideas and explanations about phenomena. These codes initially followed the codes described by Lemke (1990), but developed additional codes to reflect the data. Semantic relationships involve two words in combination to communicate some idea. The codes described below represent halves of semantic relationships.

1. Object – identifies things other than human actors.
2. Material – identifies components or compositions of objects
3. Actor – identifies the inclusion of human agents in the utterance.
4. Medium – identifies context in which a phenomena takes place.
5. Process – describes the action that takes place in an utterance.
6. Cause – describes a process that correlates the process with an outcome.
7. Attribute – describes particular features relevant to objects, actors, or media in an utterance.
8. Location – specifies places that objects, actors, or processes occur.
9. Event – specifies occurrence of a process and related outcomes.
10. Manner – describes the nature of a process.

Combinations of the semantic relationships occurred in patterned relationships. This led to creation of codes for the nature of thematic patterns that students used to construct claims and accounts. These were:

1. Circumstances/Characteristics – involved utterances whose semantic relationships claimed things about the conditions required for some phenomena to occur or qualities of phenomena that could be expected to occur regardless of context.
2. Process – involved describing or explaining the ways phenomena occur.
3. Action - involved describing human agents asserting control over phenomena in the world.

Content: What is the nature of the accounts that students jointly construct and how does this reveal the nature of students' sense-making about phenomena in the world?

Coding for the nature of the account that students jointly constructed involved looking at the claims that students made. These claims were coded to describe whether students were talking about:

1. Experiences – involve statements of observation or recounts of personal experiences that students determined were relevant to the phenomena being discussed.
2. Patterns – describe the ways that multiple observations relate to one another in a predictable way.

3. Explanations – offer reasons why patterns and experiences make sense given theories or laws of phenomena in the natural world.