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The teacher's role in the establishment of whole-class dialogue in a fifth grade science classroom using argument-based inquiry

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THE TEACHER'S ROLE IN THE ESTABLISHMENT OF

WHOLE-CLASS DIALOGUE IN A FIFTH-GRADE SCIENCE

CLASSROOM USING ARGUMENT-BASED INQUIRY

by

Matthew J. Benus

An Abstract

Of a thesis submitted in partial fulfillment
of the requirements for the Doctor of
Philosophy degree in Science Education
in the Graduate College of
The University of Iowa

December 2011

Thesis Supervisors: Professor Brian Hand
Associate Professor Soonhye Park

ABSTRACT

The purpose of this study was to examine the patterns of dialogue that were established and emerged in one experienced fifth-grade science teacher's classroom that used the argument-based inquiry (ABI) and the ways in which these patterns of dialogue and consensus-making were used toward the establishment of a grasp of science practice. Most current studies on ABI agree that it does not come naturally and is only acquired through practice. Additionally, the quality of dialogue is also understood to be an important link in support of student learning. Few studies have examined the ways in which a teacher develops whole-class dialogue over time and the ways in which patterns of dialogue shift over time. The research questions that guided this study were: (1) What were the initial whole-class dialogue patterns established by a fifth-grade science teacher who engaged in ABI? (2) How did the science teacher help to refine whole-class dialogue to support the agreeability of ideas constructed over time?

This eighteen week study that took place in a small city of less than 15,000 in Midwestern United States was grounded in interactive constructivism, and utilized a qualitative design method to identify the ways in which an experienced fifth-grade science teacher developed whole-class dialogue and used consensus-making activities to develop the practice of ABI with his students. The teacher in this study used the Science Writing Heuristic (SWH) approach to ABI with twenty-one students who had no previous experience engaging in ABI. This teacher with 10 of years teaching experience was purposefully selected because he was proficient and experienced in practicing ABI. Multiple sources of data were collected, including classroom video with transcriptions, semi-structured interviews, after lesson conversations, and researcher’s field notes. Data analysis used a basic qualitative approach.

The results showed (1) that the teacher principally engaged in three forms of whole-class dialogue with students; talking to, talking with, and thinking through ideas with students. As time went on, the teacher's interactions in whole-class dialogue became increasingly focused on thinking through ideas with students, while at the same time students also dialogued more as each unit progressed. (2) This teacher persistently engaged with students in consensus-making activities during whole-class dialogue. These efforts toward consensus-making over time became part of the students' own initiatives as each unit progressed. (3) The classroom did not engage in critique and construction of knowledge necessarily like the community of science but rather used agreeing and disagreeing and explaining why through purposeful dialogic interactions to construct a grasp of science classroom practice.

The findings have informed theory and practice about science argumentation, the practice of whole-class dialogue, and grasp of science practice along four aspects: (1) patterns of dialogue within a unit of instruction and across units of instruction, (2) the teacher's ability to follow and develop students' ideas, (3) the role of early and persistent opportunities to engage novice students in consensus-making, and (4) the meaning of grasp of science practice in classroom. This study provides insight into the importance of prolonged and persistent engagement with ABI in classroom practice.

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CERTIFICATE OF APPROVAL

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PH.D. THESIS

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To my mother Donna Lee whose steadfast love
and support helped to make all this possible

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CHAPTER ONE

GENERAL OVERVIEW AND PURPOSE OF STUDY

Introduction

In science education research the focus is ultimately on how we become literate in understanding what and how the scientific community professes and practices. In working toward this goal, research in science education often examines teaching practices and the ways in which these practices help to make students more literate to what the scientific community professes and practices. This study was an exploration into one elementary teacher's practice toward helping his students learn. This study provides a small but important contribution towards understanding the ways in which an elementary teacher's patterns of whole-class dialogue and class consensus-making activities align to how and what the scientific community professes and practices.

Science Argumentation

Helping students to become literate in science has been a widely supported goal in science education reform documents (e.g. Duschl, Schweingruber, & Shouse, 2007; NRC, 1996, 2000, 2011) that have promoted inquiry that moves beyond experiments and investigations and towards practicing science argumentation. Science argumentation is a dialogical process of making knowledge claims, providing evidence for those claims, critiquing those same claims and evidence, and reaching consensus through listening, writing, and talking (Duschl, Schweingruber, & Shouse, 2007). Dialogue occurs through the use of language. In the scientific community language is the means of the ways in which arguments are constructed, critiqued, and consented to toward understanding its questions, claims, and evidence (Kitcher, 1988; Kuhn, 1993; Lemke, 1990). In this form, learning science is not only about how to define or label words to explain content or concepts but rather about the ways in which words can be used to extend one's conceptual understanding of science.

Unfortunately, the process of engaging in science argumentation rarely occurs in science classrooms (Driver, Newton, & Osborne, 2000; Lemke, 1990; Mehan, 1979; Weiss et al., 2003). When it does occur it is only acquired through practice (Osborne, Erduran, & Simon, 2004; Simon, Erduran, & Osborne, 2006). The individual skills of assembling, presenting, discussing, critiquing, and reaching consensus are a major challenge for teachers to execute and students to be successful. Additionally, complications arise because these skills, when used in science argumentation, are not developed in isolation (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000). If students learn to practice effective science argumentation they gain new skills on how to use language to explain how and what they know and in doing so achieve some aspect of science literacy (Norris & Phillips, 2003; Yore et al., 2003).

Research conducted in the last three years also supports that science argumentation should be a core practice in science classrooms (e.g. Berland & Reiser, 2009; Jimenez-Aleixandre & Erduran, 2008; Hand, Yore, Jagger, & Prain, 2010; McNeill, 2009; McNeill & Pimentel, 2009; Sampson & Clark, 2008; Sampson, Grooms, & Walker, 2011). These researchers have worked toward understanding how argumentation might be practiced by teachers and what effect this has on student learning. These studies also agree that engaging in some aspect of science argumentation was not easy, and sufficient time and skill were required. Unfortunately these studies have not looked across longer periods of time within a given classroom to investigate the ways in which skills of science argumentation are developed, maintained, or changed as a classroom engages in the practice of science argumentation. Given the recommendation and support from researchers in science education there is a clear gap and opportunity in current research to study how science argumentation in a science classroom develops over an extended period of time.

Whole-Class Dialogue

Developing science argumentation in science classrooms is a language experience and in particular an experience that requires two or more participants to engage in dialogue (Osborne Erduran & Simon, 2004). Dialogue in this study is understood to be the ways in which people think and reflect together as ideas flow and turn (Isaacs, 1993) in ways that articulate and build common shared understanding that contribute to each other's thinking (Alexander, 2005; Fosnot, 1996; Mercer, 2000; Osborne 2007; Scardamalia & Bereiter, 2006). Through dialogue we also explore our own thoughts and how others use language to express understanding (Isaacs, 1999). Additionally, proponents of dialogic instruction suggest that dialogic interactions are reciprocal because they require that the teacher and students listen to each other and negotiate meaning as ideas are questioned, challenged, and elaborated on (Alexander, 2005; Boyd & Rubin, 2006; Harris, Phillips, Penuel, 2011; Nystrand et al., 1997).

Importantly, dialogic science classrooms engaged in science argumentation are not common (Driver, Newton, & Osborne, 2000; Lemke, 1990; Weiss et al., 2003). Many science classrooms follow the Initiation-Response-Evaluation (IRE) (Mehan 1979) or Initiation-Response-Feedback (IRF) (Sinclair & Coulthard, 1975) sequence in which the teacher initiates a question, a student responds, and the teacher provides evaluation or feedback. These patterns leave little opportunity for most students to ask or pursue their own questions. Obviously, the teacher is a key player in establishing the patterns of classroom talk that can lead to productive classroom dialogue, and as Nystrand et al., (1997) concluded, the quality of student talk is closely linked to student learning. Given the importance of quality dialogue, there is another clear gap and opportunity in current research to study the ways in which whole-class dialogue in a science classroom develops over an extended period of time.

Consensus-Making

Through science argumentation, claims and evidence ultimately must be agreed upon in order for them to be considered knowledge for the scientific community. This process of consensus-making involves many individual scientists in dialogue who are trying to construct and critique the ways in which their own ideas and the ideas of others explicitly connect to nature (Ford, 2008). This process is what Newman et al. (1989) calls a magic place where scientific negotiation happens and where consensus around the claims, evidence, and explanations explain the most and conform the best to the ways in which nature behaves (Ford & Forman, 2006). Consensus-making activities in classrooms using scientific argumentation are thought to help make presented ideas seem sensible and aid students in reasoning through their ideas (Kuhn & Reiser, 2004). But research has shown that students struggle in providing support and clarification when they do not agree with an idea (Berland & Reiser, 2009). However, when provided some structural support to justify their critiques, dialogue was found to be more complex and focused on the merits of the presented ideas (Sampson & Clark, 2009; Sampson, Grooms, & Walker, 2011). These processes of learning to engage in consensus-making and critique seem to help in the construction of knowledge in science, and thus would further support a "grasp of practice" in science (Ford, 2008). Given the importance of consensus-making efforts to support the construction and critique of ideas in science argumentation, there is another clear gap and opportunity in current research to study how consensus-making efforts in a classroom using science argumentation develops over an extended period of time.

Setting

In a review of science argumentation interventions, Cavagnetto (2010) reported on 54 articles that promoted science literacy, and of those only five (Herrenkohl & Guerra, 1998; Herrenkohl et al., 1999; Keys, Hand, Prain, & Collins, 1999; Martin &

Hand, 2009; Mason, 1996) involved elementary students doing some whole-class dialogue in science argumentation. Research from these studies affirm that children can engage in science argumentation. However it is also understood that children in this age range struggle to evaluate evidence and make sound judgments (Kuhn, 1991; Piaget, 1954). Additionally, these studies (with the exception of Martin & Hand, 2009) offer limited insight on the elementary teacher's pedagogical skill level in developing science argumentation. Given that early intervention in learning science argumentation is possible, this lack of research at the elementary level with an experienced teacher provides another clear gap in the current research that merits attention.

Purpose of the Study

This study aims to identify (1) the patterns of dialogue that were established and emerge in one experienced fifth-grade science teacher's classroom that uses science argumentation (also referred to as argument-based inquiry) and (2) how within these patterns of dialogue, consensus-making was used toward the establishment of a grasp of science practice. The purpose of this study is not to judge against approaches to science argumentation or patterns of classroom dialogue but rather to begin a conversation in the academic community about the ways in which this extended look over time at one experienced teacher's classroom practice may provide insight of what it might mean for a science classroom to have a "grasp of science" (Ford, 2008) and to be engaging in science "as argument and explanation" (Duschl, Schweingruber, & Shouse, 2007, p. 113).

Research Questions of the Study

The research questions that guide this study are as follows:

1. What were the initial whole-class dialogue patterns established by a fifth-grade science teacher who engaged in argument-based inquiry (ABI)?

2. How did the science teacher help to refine whole-class dialogue to support the agreeability of ideas constructed over time?

Rationale of the Study

In the recent publication, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2011) the authors state that the process of "developing explanations, and engaging in critique, and evaluation (argumentation) have too often been underemphasized in the context of science education" (p. 30) and researchers in science education also agree that scientific argumentation rarely occurs in science classroom discourse (Driver, Newton, & Osborne, 2000; Lemke, 1990; Mehan, 1979; Weiss et al., 2003). To complicate matters there is sufficient evidence that sustaining science argumentation in classrooms does not come naturally and is only acquired only through practice (e.g. Kuhn, 1991; Osborne Erduran & Simon, 2004). Many studies that have examined science argumentation also have focused on short interventions or only on an examination of products of argumentation (e.g., Kelly & Chen, 1999; McNeill & Pimentel, 2009; Sampson, Grooms, & Walker, 2011; Wilson, Taylor, Kowalski, & Carlson, 2010).

These and many other studies (e.g. McNeill, 2009; Sampson & Clark, 2009; Scott, Mortimer, & Aguiar, 2006) have focused on middle and/or high school classrooms, leaving only a few studies that have examined argument-based inquiry in the elementary school (e.g. Benus, Yarker, Hand, & Norton-Meier, 2011; Cavagnetto, Hand, & Norton-Meier, 2010; Chen, Hand, & Park, 2011, Martin & Hand, 2009). In summary, there are few studies that have looked at a classroom using argument-based inquiry for several days or weeks of instruction, few studies that have looked at the process of engaging in argumentation, and only a few studies that have occurred in elementary classrooms.

The present research legacy, in effect, provides insufficient evidence of the dialogical practices needed to develop and engage over time an elementary science classroom community in argument-based inquiry. While this study will not provide sufficient evidence of the dialogical practices needed over time for any elementary science teacher, it will provide the research community with one example of how one elementary science teacher engaged his students in argument-based inquiry. This study can serve as one look at the ways in which one teacher using argument-based inquiry over time helped students engage in whole-class dialogue toward the establishment of a grasp of science practice.

Overview of the Study

In this chapter, the rationale for studying whole-class dialogue in argument-based inquiry in an elementary science classroom has been addressed. The research questions and the significance of the study have also been stated.

Chapter Two discusses science argumentation as a core practice of science and how science argumentation is also seen as an important practice in science classrooms. Instructional approaches to science argumentation are also discussed. The role whole-class dialogue, approaches to studying dialogue, and patterns of classroom talk are also reviewed. Additionally, the role of critique and consensus-making is discussed. Finally, the theoretical and conceptual framework around an interactive-constructivist view is discussed and the ways in which the framework guided the analysis and interpretation of findings.

Chapter Three provides a rationale for use of qualitative methods to study whole-class dialogue and how the teacher during these episodes of whole-class dialogue engages students in consensus-making activities. In order to answer the two research questions, the chapter discusses the reasons for a basic qualitative approach. The rationale for selecting the teacher, data collection types and procedures, and the ways in which the data was analyzed are discussed. Finally, trustworthiness for this study in terms of establishing credibility, transferability, and dependability is also discussed in this chapter.

Chapter Four discusses the findings from the two research questions for this study. Five major findings are identified from this study: (1) The analysis of patterns of talk showed that the teacher talked less as time went on while the overall total time of students in talk and activity increased as time went on, (2) Three patterns of talk in the first unit of instruction are nearly equally shared across time while by the end of the second unit one type of talk pattern dominated, (3) patterns of talk before or after students episodes of talk shifts over time from talking to students to thinking through ideas with students, (4) early in the 18 weeks of the study the teacher provided many opportunities for students to engage in consensus-making activities, and (5) the classroom's engagement in critique by the end of the second unit was still under development. Overall, the findings suggest that patterns of dialogue shifted for the teacher as students began to demonstrate abilities to talk with each other about their own ideas and to be able to agree/disagree and explain why.

Finally, Chapter Five discusses the findings of this study in terms of three areas: (1) the implications that shifting patterns whole-class dialogue had on the ability of the class to engage in argument-based inquiry, (2) the role that consensus-making had on helping students to construct an understanding of the ideas presented, and (3) the way in which dialogue and consensus-making helped the classroom community to have a grasp of the ways in which science is practiced. Finally the implications for teaching, future research, and limitations for this study are also discussed.

CHAPTER TWO

LITERATURE REVIEW

In this chapter, the researcher explores the role of argumentation in science, the ways in which argumentation is practiced in science classrooms, what dialogue is and the ways in which this is researched in science classrooms. The researcher then develops a framework for studying whole-class dialogue. Also discussed in this chapter is support for the ways in which the Scientific Writing Heuristic (SWH), an argument-based inquiry approach, is a fruitful approach to understanding the development of whole-class dialogue and "grasp of practice" of science over time. Furthermore, this chapter also explores studies that included whole-class discourse and suggests the future work that could provide significant implications for classroom practice of argument-based inquiry.

Argumentation as a Core Practice of Science

Science is a social process that constructs knowledge in and through people (Kuhn, 1993; Newton, Driver, & Osborne, 1999; Westrum, 1989). It is through language that we come to understand science. Yet, how we discuss the process of understanding and practicing science is also bound up within the tangled web of language. Language is essential for scientists to explain and argue for their ideas. Scientists use language not only for inquiry but also as an inquiry approach (Wallace et al., 2004). Language, in particular the way the scientific community uses language, is a critical component of the ways in which one becomes literate in science (Jiménez-Aleixandre & Erduran, 2008). For the scientist, science argumentation is the principle method of the means by which scientific knowledge is developed (Kitcher, 1988) and a significant component of the manner in which scientific discourse happens (Kuhn, 1993; Lemke, 1990). Through argumentation we learn to think (Billig, 1996). Deanna Kuhn (1992) emphasized thinking as argument saying:

> It is in argument that we are likely to find the most significant way in which higher order thinking and reasoning figure in the lives of most people. Thinking as argument is implicated in all of the beliefs people hold, the judgments they make, and the conclusions they come to; it arises every time a significant decision must be made. Hence, argumentative thinking lies at the heart of what we should be concerned about in examining how, and how well, people think (Kuhn, 1992, p. 156).

Defining Science Argumentation

Science argumentation can be defined as a dialogical process of making knowledge claims, providing evidence for those claims, and critiquing those same claims and evidence through listening, writing, and talking (Duschl, Schweingruber, & Shouse, 2007). Science argumentation assumes that truth is not a necessary condition, desired outcome, or something held by any one person or group. By engaging with and in scientific argumentation, scientific knowledge is claimed because it carries with it tentative, but stable, evidence that is deemed trustworthy by the community of science (Gross, 1990). Scientific argumentation can be thought of as a cyclical process that is refined and matured as knowledge claims and supporting evidence are revised and reworked as new understandings emerge over time. (von Aufschnaiter et al., 2008; Berland & Reiser, 2011; Chin & Osborne, 2010; Kuhn 1992; Lawson, 2003; Wellington & Osborne, 2001).

Science Argumentation as a Social Process

Science argumentation can be thought of as occurring at the individual level and the broader social level (McNeill, 2009). On the individual level a person considers and justifies his or her own ways of knowing through listening, writing, his or her own reasoning, and empirical evidence. He or she constructs his or her own understanding as to what he or she believes to support his or her thinking (Driver et al., 2000; McNeill, 2009). In this way, individuals first argue with themselves to come to develop their assertions. McNeill, in explaining argumentation at the social level, writes about argumentation as a process of the individual writing and/or talking to inform others about individual assertions and to be placed in a position to justify and defend those assertions with and among others. However, McNeill points out, both individual and social aspects do happen, but the social aspects are an essential component. Science argumentation is clearly a language-based and social process, because at the individual or broader social level it involves understanding and interacting with the ideas of someone besides self (Vygotsky, 1978).

Because argumentation can be chiefly thought of as a social process and practice it can also be thought of as an essential social skill that should be part of our schooling. The Organisation for Economic Cooperation and Development sees the ability to examine and critique evidence as an important life skill. It states:

> An important life skill for young people is the capacity to draw appropriate and guarded conclusions from evidence and information given to them, to criticize claims made by others on the basis of the evidence put forward, and to distinguish opinion from evidence-based statements. Science has a particular part to play here since it is concerned with rationality in testing ideas and theories against evidence from the world around. (OECD, 2003, p. 132)

By engaging in this life skill, students participate in science discourse and assume an emerging role within the community of practice (Wenger, 1993). In assuming these practices of science argumentation within a classroom community of learners, students benefit from being apprenticed in situated practices (Brown & Campione, 1990; Collins et al., 1989) of the community of science. This type of authentic engagement helps students to explore their own everyday scientific theories such as those they brought with them into class. One's everyday theories could be challenged in authentic and relevant ways (Innes, 2006). The classroom community can critique another's thinking through science discourse in the light of their own thinking and that of experts (Newton, Driver, & Osborne, 1999). In terms of classroom dialogue Newton, Driver, and Osborne (1999) state, "In talking, learners will articulate reasons for supporting particular conceptual understandings and attempt to justify their views. Others will challenge, express doubts and present alternatives, so that a clearer conceptual understanding will emerge" (p. 554). Through this sort of engagement, thinking and reasoning is made overt and further aligns to authentic science practice. Additionally, and perhaps most importantly, these opportunities to listen, talk, and write in and through science argumentation also help students in achieving the goal of science literacy, because science cannot advance without the use of language (Norris & Phillips, 2003, Yore et al., 2003).

Science Argumentation as a Core Practice in Schools

An emphasis on using science argumentation in schools began in the early 1990's when Kuhn (1992, 1993) and Lemke (1990) began publishing the ways in which classrooms might benefit from engaging in the learning processes found among practicing scientists. As scientists engage in argumentation they modify their ideas by making or critiquing claims which strengthen their understanding within their domain of study. This effect of strengthening understanding over time through argumentation began to be researched in K-12 education. It was determined that argumentation should also be a critical component of instruction in our science classrooms (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002; Kuhn, 1993) in an effort to help students learn. Reform-based publications in science education have promoted the use of inquiry in science classrooms that aligns to scientific argumentation (Duschl, Schweingruber, & Shouse, 2007; NRC, 1996, 2000). For example, the *National Science Education Standards* (NRC, 1996) and *Taking Science to School: Learning and Teaching Science in Grades K-8* (Duschl, Schweingruber, & Shouse, 2007) discuss the need to move science classroom practice beyond experimentation and investigation towards classrooms engaged in science "as argument and explanation" (p. 113). Many other science education researchers agree (Berland & Reiser, 2009; Driver, Newton, & Osborne, 2000; Duschl, 2008; Jimenez-Aleixandre & Erduran, 2008; Hand, Yore, Jagger, & Prain, 2010; Kuhn, 1993; Kuhn, 2010; Norris &

Phillips, 2003; Osborne, Erduran, & Simon, 2004; Sampson & Clark, 2008; Sampson, Grooms, & Walker, 2011; Simon, Erduran, & Osborne, 2006) and have supported the conception of science argumentation as core practice to establish in science classrooms, because it not only helps with understanding of scientific concepts but also helps in improving students' understanding of the nature of science and science literacy.

Without argumentation, the students' ability to construct and critique knowledge may be compromised (Ford, 2008). If students are not empowered with opportunities to critique, they are placed in a position that leaves their own ideas uncontested, or they are expected to accept an idea "held by the individual with the most clout (e.g. the teacher...)" (Berland & Reiser, 2009, p. 1). When empowered, for example, students can ask "why" questions instead of "what" questions (Duschl, 1990). It is "why" questions that can help to engage students into the core practices found in communities of scientists, as these questions set up conversations and critique around data, claims, and evidence, all of which are core essential components of scientific argumentation (Bricker & Bell, 2008). Additionally, by engaging in argumentation students must conceptualize the written or spoken thoughts of others and in doing so their thoughts are developed (Vygotsky, 1987). When students talk or write in response, their "thought is restructured as it is transformed into speech. It is not expressed but completed in word" (Vygotsky, 1987, p. 251). This transformation of thought into words and back into thought over and over again can only help in supporting knowledge construction.

The Practice of Science Argumentation in School Settings

Scientific argumentation rarely occurs in classroom discourse (Driver, Newton, & Osborne, 2000; Lemke, 1990; Mehan, 1979; Weiss et al., 2003). Of the studies cited in this literature review where argumentation was being practiced, most were affiliated with a research-based program or with intervention from one or more of the study authors (e.g. Clark & Sampson, 2008; Martin & Hand, 2009; McNeill & Krajcik, 2008; Simon, Erduran, & Osborne, 2006; von Aufschnaiter, Erduran, Osborne, & Simon, 2008). This should not be regarded as good or bad, but rather as further support for the notion that finding classrooms anywhere in the world engaged in science argumentation without ties to recent or ongoing emerging professional development models are scarce. This means that the ways in which a classroom approaches science argumentation may be largely based on the manner in which the teacher is initially introduced and trained in the research-based program. In a recent review of 54 argument interventions in peer-reviewed literature, Cavagnetto (2010) recognized four types of patterns of the ways in which scientific argument were being used: a) explicit instruction of the structure of argument, b) immersive instruction, and c) socio-scientific instruction. Ten of the interventions were geared toward learning structure of argument, twenty-two of the interventions were immersion-based, three contained both structure and immersion, fifteen were socio-scientific, and three were not easily classifiable.

Explicit Instruction of Science Argumentation

In the first pattern, learning through explicit instruction focuses on the way to use and structure an argument in science. Simon, Erduran, and Osborne (2006) point out from Kuhn's (1991) research that for the overwhelming majority "…the use of valid argument does not come naturally and is acquired only through practice" (p. 6). They then state that "…argument is a form of discourse that needs to be explicitly taught, through the provision of suitable activity, support, and modeling" (Simon, Erduran, Osborne, 2006, p. 6). Their work with the IDEAS project (Erduran, Simon, & Osborne, 2004; Osborne, Erduran, & Simon, 2004; Simon, Erduran, & Osborne, 2006; von Aufschnaiter, Erduran, Osborne, & Simon, 2008) would support their claim and a pattern type identified by Cavagnetto (2010). Work by McNeill and others (McNeill, 2009; McNeill, Lizotte, Krajcik, & Marx; 2006; McNeill & Krajcik, 2008; McNeill & Pimentel, 2009) would support explicit instruction of argument as well. In the IDEAS project students were first taught Toulmin's (1958) argument structure that focuses on written argument. This was then applied to nine topics, and students were asked to evaluate and explain competing ideas. In McNeill's and colleagues' work, students were taught first how to construct explanations. Students used a claims, evidence and reasoning structure that was deemed as more suitable and easier to understand by students than Toulmin's argument structure. Although both research groups used different but related argument products, the structure of argument was explicitly emphasized (e.g. warrants and backing or reasons why) to first teach argumentation.

Immersive Instruction of Science Argumentation

In the second pattern, immersion in science focuses on learning scientific argument in investigative contexts. Gee (2004) views language as always occurring within a context and should be embedded within a learning experience. Hicks (1995) suggests that academic discourses are learned through repeated participation in social activity (Rogoff, 1990) and that teachers can provide "discursive slots" that help learners to participate. Each of these perspectives (Gee, NRC, and Hicks) provides ample support for immersion practices in science argumentation. Cavagnetto's (2010) review identified twenty-two studies that had immersion-based practices. Overall, the interventions used scaffolds, group collaboration, and cognitive conflict to help with argument construction. In work by Clark and colleagues (Clark & Sampson, 2007, 2008; Clark, D'Angelo, & Menekse, 2009), cognitive conflict was used to support argument through a computer program that placed students in groups based on differences in their initial explanations. In work by Hand and colleagues (Keys, Hand, Prain, & Collins, 1999; Martin & Hand, 2009), they used scaffolding approaches to help students construct arguments by prompting questions about their own researchable question, claim, evidence, and the ways in which those questions and responses compare with others. The scaffolding through questioning helped students to be immersed in questions, claims, and evidence that are at the core of science argumentation. In work by Sandoval and colleagues (Sandoval & Millwood, 2005; Sandoval & Reiser, 2004), computer programs to help students scaffold relationships between their investigative work and explanation. In each of these three representative research groups, the classroom instruction in elements of argument emerged as skills were needed.

Socio-Scientific Instruction of Science Argumentation

In the third pattern, interactions between science and society (socio-scientific) were used to learn scientific argument. These interactions involved moral, ethical, and political decision-making around matters of science, society, and technology (Sadler & Donnelly, 2006; Sadler & Fowler, 2006; Kolsto, 2001, 2006; Wu & Tsai, 2007). These interventions usually occurred as culminating activities in the form of debate. With this approach argumentation is portrayed as an outcome of practice rather than an essential ongoing practice of science. Additionally, debating the merits of scientific claim in the light of morals, ethics, and politics may not lead to a valid argument (Osborne, Simon, & Erduran, 2004), or may lead to a misunderstanding of the extent to which a scientific claim can align to moral, ethical, or political ways of knowing and debating. Lastly, science argumentation is rooted in negotiating empirical work and far less, if at all, is concerned with moral, ethical, and political arguments that may arise from the knowledge constructed by a science community's practice (Ford & Forman, 2006).

Explicit and Immersive Instruction of Science Argumentation

The fourth pattern type of interaction found was a combination of explicit and immersion forms. In one example, Herrenkohl and Guerra (1998) combined these two forms and explicitly taught 8-10 year olds specific audience roles for encouraging productive scientific argumentation. After teams of 4th graders presented their work students were expected to assume those roles. They found that those classrooms had increased negotiation of shared understanding and had better coordination of theory and evidence. This fourth pattern can be seen as hybrid approach where explicit instruction happens along with immersion activities in an authentic inquiry context.

Summary of Instruction Practices of Science Argumentation

Each of these interactions provides a thoughtful picture of the ways in which an approach to learning science argumentation takes place in school settings. Developing science argumentation in science classrooms is first and foremost a dialogic event among two or more participants (Osborne, Erduran, & Simon, 2004), and sustaining argument in classrooms does not come naturally; it is only acquired through practice (Kuhn, 1991). However, Duschl, Ellenbogen, & Erduran (1999) found that students do have a natural tendency to engage forms of argument when a sound context is provided. In classrooms using immersion activities, perhaps there is strong alignment of dialogic opportunity, embedded practice, and sound context for science argumentation to take place. Cavagnetto (2010) in support of immersion, says "…through immersion, students have the opportunity to authentically wrestle with fundamental elements of science (e.g., control of variables, error, data transformation, etc.). According to Ford (2008), these fundamental elements of science are uncovered as students engage in construction and critique of ideas (argument) throughout investigations" (Cavagnetto, 2010, p. 352). Cavagnetto and Ford support immersion as the preferred approach because it situates the learning (Lave & Wenger, 1991) of science because learners through immersion are afforded opportunities to increase their participation over time in science argumentation.

Dialogue as the Core Feature of Science and Learning

In this section of the literature review the researcher will discuss what is dialogue and the way in which this relates to science argumentation. While a definition of dialogue clearly encompasses listening, talking, reading, and writing, the focus of this review will be on dialogue as listening and talking in the context of science and learning. This is not to suggest that reading and writing are not important to developing dialogue in science argumentation or learning. Studies by Reznitskaya et al. (2001) and Rivard and Straw (2000) examined both talk and writing in the classroom setting and concluded that opportunities to talk before writing generally improved the quality of a student's written response. Nystrand et al. (1997) examining the dynamics of language and learning concluded, "…the bottom line for instruction is that the quality of a student learning is closely linked to quality of classroom talk" (p. 29). Talking and writing are essential elements of dialogue, but this portion of the review will primarily refer to dialogue as listening and talking.

What is Dialogue?

Dialogue as a word has is roots in ancient Greek and comes from the Greek roots of "dia" and "logos" and can be roughly translated as "meaning flowing through" (Isaacs, 1993, p. 25). All dialogues begin with conversation, and the root word converse means "to turn together" (1993, Isaacs, p. 35). It is worth noting that conversation starts a dialogue, but the two are not synonymous. Isaacs, an organizational communication scholar in his book, *Dialogue and the Art of Thinking Together* (1999) says "Dialogue is properly a gift relationship...When we speak together in a dialogue, we are speaking in a way that seeks to contribute one to the other. A conversation where the people are essentially trying to extract something from others moves away from dialogue" (Isaacs, 1999, p. 393). Practicing dialogue engenders further thinking (Fosnot, 1996) as voices flow through and turn and refract another (Bakhtin, 1984; Isaacs, 1993; Nystrand, et al, 1997).

Dialogue can be thought of as generative. Dialogue builds groups that can think together about their own ideas in the light of another's (Schein, 1993). Dialogue is a "way of thinking and reflecting together. It is not something you do to another person. It is something you do with people" (Isaacs, 1999, p. 9). In dialogue, "voices interpenetrate one another and thereby constitute and change one another" (Baxter, 2004, p. 186). In generative dialogue we create a "safe container" (Isaacs, 1999, p. 373) in which dialogue is jointly owned, shared, respected, and is a place where we can have a "common text that anyone can edit" (Isaacs, 1999, p. 373). Additionally, it is a place that is committed to progress, expansion and/or modification of take-as-shared ideas (Scardamalia & Bereiter, 2006).

Dialogue also flows. Feedback is discouraged. Schein, a colleague of Isaacs and fellow organizational communication scholar, says this about feedback and dialogue:

> In dialogue, the whole group is the object of learning, and the members share the potential excitement of discovering, collectively, ideas that individually none of them might have ever thought of. Feedback may occur, especially in relation to individual behavior that undermines the natural flow of conversation, but it is not encouraged as a goal of the group process (Schein, 1993, p. 30-31)

Dialogue is also tentative and is a reasoning tool. Through dialogue we explore the complexity of thought and language, we highlight how arbitrary our thoughts and perceptions are, and we become aware of our own bias toward thinking (Schein, 1993). Schein describes how, in dialogue, others help us to see ideas differently through shared experiences. He states, "As we listen to ourselves and others in what may appear often to be a disjointed, rather random conversation, we begin to see the bias and subtleties of how each member thinks and expresses meanings. In this process, we do not convince each other, but build a common experience base that allows us to learn collectively" (Schein, 1993, p. 34). There is strong commitment to a shared understanding rather than agreement (Scardamalia & Bereiter, 2006). In this way engaging in dialogue helps make our own reasoning and sense making tentative and pliable because dialogue fosters suspension and reflection of ideas rather than a need for immediate evaluation and feedback (Isaacs, 1999).

In summary, dialogue is far more than simply talking or having a conversation with others. In a similar fashion, engaging in science argumentation is not the same as simply discussing or arguing about something with others. However, talking, conversing, discussing, and arguing do have their places when we communicate with others, but they are limited when they are not immersed as elements of dialogue. In the cases of science argumentation and dialogue there seems to be a hand-in-glove fit. In science and in dialogue, ideas need to come from reliable sources yet regarded still as tentative. Methods and patterns of interaction and discovery have form but are not fixed. Contributions by all are valued. Knowledge builds through consensus as the community engages with and in practice. Lastly, dialogue like science is generative, as it always ends with an invitation to engage in further inquiry (NRC, 2000).

Whole-Class Dialogue in Classrooms

Classrooms with an orientation toward fostering whole-class dialogue would obviously be places that involve and promote some of the features of dialogue that were noted earlier. Proponents of dialogic instruction (e.g. Alexander, 2005; Boyd & Rubin, 2006; Christoph & Nystrand, 2001; Gambrell & Almasi, 1996; Wells, 1996; Wells & Chang Wells; 1992) suggest that eight keys factors are needed in order to set up dialogic instruction: (a) classroom environment promotes collectively engaging and learning tasks together (Alexander, 2005; Boyd & Rubin, 2006); (b) classroom environment is reciprocal with all listening to each other and considering alternative viewpoints (Alexander, 2005; Osborne 2007); (c) as ideas are articulated there is ample support for helping each other to reach common understandings (Alexander, 2005; Osborne 2007); (d) dialogic instruction is cumulative and collective as all build on their own and each others' ideas (Alexander, 2005; Mercer, 2000; Osborne 2007); (e) classroom environment is relatively unpredictable because it is negotiated as teachers and students pick up on, elaborate, and question what students say (Boyd & Rubin, 2006; Harris, Phillips, Penuel

2011; Nystrand et al., 1997, p. 7), (f) dialogical interactions involve fewer teacher questions and more conversational turns (Boyd & Rubin, 2006), (g) the teacher's voice is one of many voices, though likely a "critically important one" (Nystrand et al., 2003, p. 187), (h) decisions are purposeful in that teachers plan well-defined educational goals in support of dialogue (Alexander, 2005; Osborne 2007). In all these ways of representing dialogic instruction, it is teaching and learning that goes well beyond the "two people talking" stereotype (Burbules & Bruce, 2001, p. 15). Additionally Burbules and Bruce (2001) stated, "No single approach holds the patent on dialogue and it is even 'undialogical' to think it can" (p. 15).

The dialogic classroom also creates a space where interactions with classmates and teacher traverse Vygotsky's (1978) zone of proximal development (the difference between what learners can do without help and what they can do with help) (Innes, 2006). A classroom in dialogue cannot be a place of mostly passive recipients of knowledge and instruction. Dialogue, like science, is a collective activity where no one person claims ownership, nor does one construct a shared understanding without first having a shared experience (Klein, 2006). Students in order to become engaged with science as a community of practice, must find value in attending to the claims and evidence of classmates (Kuhn & Reiser, 2006). Students must relate what they hear and see with their own ideas. Knowledge from and through dialogue requires it to move back and forth from thought to speech and thus enhance learning (Klein, 2006, p. 154).

A dialogic classroom, and in particular a dialogic science classroom, engaged in science argumentation is not common. Many science classrooms follow the Initiation-Response-Evaluation (IRE) (Mehan 1979) or Initiation-Response-Feedback (IRF) (Sinclair & Coulthard, 1975) sequence in which the initiating question gets some sort of response by a student and either feedback or evaluation by the teacher (also see Lemke 1990). This type of pattern leaves little incentive for other students to engage with the teacher, or in peer-to-peer dialogue. There are also closed chain sequences that are I-R-

R-R-P-R-R-E (or some other variation R's and P's) that start with the teacher initiating, followed by student responses, leading to a teacher prompt (P) (e.g. 'that's interesting, tell me a little more…') and eventually ending in evaluation or feedback by the teacher. Lastly, there are "open chains" of interaction that follow the same formats noted above, but without evaluation or feedback by the teacher (Mortimer & Scott, 2003). It is also possible that in open chains these start or end with students rather than with the teacher (Mortimer & Scott, 2003).

It is the teacher who ultimately must intervene to foster the productive dialogue (Duschl, Schweingruber, & Shouse, 2007). Wells (2005) notes that the way the sequence starts is far less important than the choice of roles the teacher utilizes as the dialogue develops. The number of consecutive turns of talk by students and the length of each turn does not equate to dialogue (Wells, 2005). Rather, the extent to which the teacher and students' voices "interanimate" (Bakhtin, 1986) can be heard and thought of as dialogue (Wells, 2005). In summary, without teacher intervention students do not spontaneously adopt productive dialogic discourse (Osborne et al., 2001).

Approaches for Studying Discourse in Classrooms

The literature is scarce that describes approaches to studying whole-class discourse in classrooms using some form of science argumentation. Most of the literature looks at the written products of science argumentation or at a particular aspect of class dialogue (e.g. group work or student only talk) rather than whole-classroom dialogue. Unfortunately, not one of the approaches discussed below in this portion of the review used argument-based inquiry where students were responsible for generating their own questions, data, claims, evidence, and reasoning.

Among the first traditions to study whole-class dialogue were those that were systematic in their approach by having some type of tick-box protocol that was binary or Likert-scale in nature with predetermined categories (e.g. Amidon & Giammatteo, 1967;

Pankratz, 1967). In the 1970's studies began to explore the social organization of classroom lessons, placing emphasis on discourse analysis. From this work came discussions of Initiation-Response-Feedback (IRF) (Sinclair & Coulthard, 1975) or Initiation-Response-Evaluation (IRE) (Mehan 1979) in classrooms. Even today it is widely referenced and considered as a benchmark of sorts for comparing changes in classroom talk. Work by Douglas Barnes (e.g. Barnes, 1971, 1973, 1976, Barnes & Todd, 1977) took on a more interpretative approach to studying classroom dialogue. His work centered on classroom talk as fundamental to student learning. He was able to record student talk and transcribe it for further analysis. In this regard, he was a pioneer in his approach to data collection and analysis. This approach is still widely practiced today. Edwards and Mercer (1987) and Mercer (1996) also did similar follow-up work and will be discussed in greater detail below. Additionally, Mortimer and Scott's (Mortimer, 1998; Scott, 1998; Mortimer & Scott, 2000, Mortimer & Scott, 2003) communicative approach (in science classrooms) has been widely discussed in the literature and will be discussed in greater detail below.

An interpretative Approach to Studying Discourse in Classrooms

The book by Edwards and Mercer (1987) book *Common Knowledge: The Development of Understanding in the Classroom* is a widely cited publication that considers the development of 'common knowledge' through classroom talk. The book focuses on issues of control of learning in and between teachers and students. They found that in student-centered classrooms the teacher's focus is on cognitive socialization rather than on individual discovery. Though widely cited for their notion of 'common knowledge', their findings on the features of classroom discourse or the teacher's focus in student-centered classrooms were not found in science education literature. Edwards and Mercer identified the following features of classroom discourse: (a) elicitation of students' contributions; the teacher asks questions while simultaneously providing explicit clues to the information required; (b) cued elicitation of students' responses; draw out from students the information they are seeking (type of Socratic dialogue constructed by Plato); (c) significance markers; these are special enunciations repeating of keywords by the teacher showing that a word, phrase, or idea has some special value; (d) joint-knowledge markers; the teacher uses global or royal "you" or "we" in highlighting something; (e) reconstructive recaps; the teacher re-presents an idea said by teacher or student which may move it from "lay person" language to more "scientific" language, (f) paraphrastic interpretations; of students' contributions, paraphrasing something said by a scientist; (g) direct lecturing; the teacher is delivering content to students.

About a decade later, Mercer (1996) again looked into classroom talk in an elementary school while students worked in small groups on collaborative tasks. He described three ways of talking and thinking: disputational talk, cumulative talk, and exploratory talk. Disputational talk is characterized by disagreement as an individual and often consists of short assertions and counter-assertions. In disputational talk, offering or accepting constructive criticism is not often practiced. In cumulative talk, students build on each other's ideas but these are often repetitions, confirmations, or elaborations rather than a critical look at what common knowledge was being built. Finally, in exploratory talk students engage critically but constructively with each other. Ideas are considered jointly and sometimes challenged or counter-challenged. Progress happens when joint agreement is reached.

In these two interpretative cases of studying discourse in classrooms, it is worth noting that both their findings did not come from science classrooms, and the 1996 study was based on small-groups and not whole-class dialogue. However, the results very clearly articulate two important points. First, in Edwards and Mercer's (1987) study, discourse in student-centered classrooms focused on cognitive socialization rather than individual discovery. Each of those discourse features support the fact that learning from others, and not necessarily because they are more competent, happens because each time an elicitation, marker, or recap happens as spoken language it is always different, and helps to foster new ways of thinking with and thinking through ideas (Baxter, 2004; Mercer, 2000, Vygotsky, 1987; Wertsch, 1991). In Mercer's (1996) study he states, "The concepts of disputational talk, cumulative talk and exploratory talk are embryonic models of three distinctive social modes of thinking, models which could help us understand how actual talk (which is inevitably resistant to neat categorization) is used by people to think together" (Mercer, 1996, p. 369). For example, disputational talk seems to be a talking to mode while exploratory talk is a talking with and thinking through mode in which ideas are open to be constructed and critiqued (Ford, 2008) with others.

A Communicative Approach to Studying Discourse in Classrooms

Mortimer and Scott's (2003) book, *Meaning Making in Secondary Science Classroom*, uses a framework from socio-cultural theory and was developed through empirical analysis of talk in secondary science classrooms in England and Brazil. In the English classroom, analysis consisted of nine lessons on rust (chemical reactions) and was for the most part whole-class interactions. In the Brazilian classroom, analysis consisted of twelve lessons on particle theory in small group and whole-class discussions. Their work resulted in a framework that helps to explain how teachers help students to construct meanings through varying forms of discourse and interactive patterns. The approach looks at the ways in which the teacher interacts with students, and the manner in which the teacher takes into account student ideas as the lesson progresses. Their analysis resulted in four fundamental classes of communicative approach. They are represented along two dimensions; dialogic/authoritative and interactive/non-interactive. The authoritative and dialogic dimension is based the writing of Bakhtin (1981) later discussed by Wertsch (1991). Mortimer (1998) initially used the dialogic/authoritative dimension in analyzing discourse from a Brazilian classroom.

The Dialogic/Authoritative and
Interactive/Non-Interactive Dimensions

Authoritative talk can be understood not to foster the bringing together or exploration of ideas. During authoritative talk, when other ideas or questions are raised that do not contribute to the development of the one idea or ideas, these ideas or questions are ignored or re-voiced back to the lesson's focus. If ideas are raised that the teacher sees as developing the lesson, they are used and well regarded. Other talk or discourse that does not support the teacher's approach to the development of the lesson story is not advanced. Many students may talk, but exploration only of the teacher's perspective happens. In this way there is no interanimation of ideas (Bakhtin, 1981) in which there is repetition of utterances of the other, expression of some reaction, some notion of comprehension. In contrast, dialogic discourse is understood to be open and to encourage different points of view. Throughout the lesson or sequences of lessons they dialogue about ideas. In the beginning, dialogue may consist of talking with students concerning their everyday thoughts about some aspect of science. In later lessons the teacher might help students in thinking through as their ideas are changing through experimentation, research, and further dialogue. In this way there is an interanimation of ideas (Bakhtin, 1981). Talk is considered interactive when many can and do participate.

Talk is non-interactive when some are excluded from participation. These two dimensions when combined can represent four types of classroom communication; interactive/dialogic, non-interactive/dialogic, interactive/authoritative, non-interactive/authoritative. Table 2.1 shows this representation. Scott, Mortimer, and Aguiar (2006) describe these four classes as:

a. Interactive/dialogic: Teacher and students consider a range of ideas. If the level of interanimation is high, they pose genuine questions as they explore and work on different points of view. If the level of interanimation is low, the different ideas are simply made available.

b. Non-interactive/dialogic: Teacher revisits and summarizes different points of view, either simply listing them (low interanimation) or exploring similarities and differences (high interanimation).

c. Interactive/authoritative: Teacher focuses on one specific point of view and leads students through a question and answer routine with the aim of establishing and consolidating that point of view.

d. Non-interactive/authoritative: Teacher presents a specific point of view.

(Scott, Mortimer, & Aguiar, 2006, p. 611-612).

Table 2.1 Four Classes of Communicative Approach

	Interactive	Non-Interactive
Dialogic	Interactive / Dialogic	Non-interactive / Dialogic
Authoritative	Interactive / Authoritative	Non-interactive / Authoritative

Source: Mortimer, E. F., & Scott, P. H. (2003). *Meaning making in secondary science classrooms*. Maidenhead, UK: Open University Press.

It is inevitable that tension will exist with these four classifications in every teaching moment. Mortimer and Scott (2003) conceptualize dialogical teaching as movement between these different classes. One type of interaction may be needed at one moment while the three others may not be appropriate in aiding dialogical teaching. The key in this claim is that Mortimer and Scott see the four together as *dialogical teaching* rather than dialogic talk. Additionally their work also suggests that there is not a dialogic or non-dialogic binary with respect to teaching. As mentioned earlier in this literature review, "it is teaching and learning that goes well beyond the "two people talking stereotype" (Burbules & Bruce, 2001, p. 15). Additionally Burbules and Bruce (2001) state, "No single approach holds the patent on dialogue and it is even 'undialogical' to think it can" (p. 15). However, a critical point must be made. If what happens in the classroom is about student learning, these four classifications of dialogic teaching may not be in harmony with what was defined as dialogue earlier in this literature review. Isaacs (1999) says "dialogue is properly a gift relationship... When we speak together in a dialogue, we are speaking in a way that seeks to contribute one to the other. A conversation where the people are essentially trying to extract something from others moves away from dialogue" (p. 393). Practicing dialogue engenders further thinking (Fosnot, 1996) as voices flow through and turn and refract another (Bakhtin, 1984; Nystrand, et al, 1997; Isaacs, 1993). Mortimer and Scott's notion of dialogical teaching is potentially a real threat to whole-class dialogue because interactive/authoritative and non-interactive/authoritative classifications are about presenting or consolidating a singular point of view. With two of the four classifications as potential threats to whole-class dialogue, a careful look should be considered into how much authoritative talk a classroom can have and still be dialogic.

Classrooms that engage in scientific argumentation engage in "activity, reflection, and conversation" (Fosnot, 1989, p. 29). In later writings Fosnot states; "The learners (rather than the teacher) are responsible for defending, providing, justifying, and communicating their ideas to the classroom community. Ideas are accepted as truth only insofar as they make sense to the community and thus rise to the level of "taken-as-shared," (Fosnot, 1996, p. 29-30). However Mortimer and Scott and likely many others would say the teacher is very much part of this community's efforts along the dialogic dimension. Fosnot is radically cutting short the teacher's role in promoting and engaging the ways to come to know and practice "taken as shared". McNeill (2009) states, "The teacher can be essential for helping students explain phenomena, justify the claims they are making, and debate the strength of alternative explanation" (p. 259). Argumentation once in full practice is thought to "transform the common monologic discourse of the school science classroom" (Osborne, 2007, p. 12) that is often wrought with "monolithic paths of logic or pre-ordained discovery" (Yerrick, 2000, p. 814) led or voiced by the teacher. Therefore, the authoritative dimension, which never can be silent in the classroom, in excess could be seen as a threat to whole-class dialogue.

Relationships Among Approaches to Studying Classroom Discourse

Considering the work of Edwards and Mercer (1987), Mercer (1996), and Mortimer and Scott (2003), they have provided three different, but related, ways of conceptualizing dialogue in classrooms. From the vantage point of this researcher, three overarching ways of understanding the teacher's practice in whole-class dialogue can be conceptualized from these studies. First was the teacher talking to (TT) students, second, the teacher talking with (TW) students, and finally, the teacher thinking through (TH) ideas with the students.

Talking To (TT) Students

Each of these studies describes the teacher at some point in a lecture, recitation, or monologue format talking to (TT) students as the primary activity. The focus activity during some of these types of moments is what Bakhtin called "official discourse" (Holquist, 1990). Such would be the extreme view of this type of talk in which the teacher's comments would become the outer speech of all (Holquist, 1990, p. 52). Bakhtin also referred to this type of talk as a singular mode of cognitive interaction in which known truth is instructed to someone ignorant of it (Bakhtin, 1984, p. 81). Duschl and Osborne (2002) remind us that "normal classroom discourse is predominantly monologic" (p. 55). This normal type of talk Bakhtin called, "pedagogical dialogue" that inverts the natural flow of inquiry (Bakhtin, 1986) but may adequately convey meanings and provide a shared memory for the group (Lotman, 1998) . Monologic talk then is marked by one voice, one idea (Roth, 2009, p. 83). Lastly Wells and Mejía (2005) point out, “A further drawback is that, in this transmissionary model of communication, although intersubjectivity is assumed, it cannot be guaranteed, because there is no opportunity for misunderstandings or misinterpretations by the receiver(s) — which inevitably arise — to be corrected” (Wells & Mejía , 2005, p. 385). In this way, what is understood by students from talking to transmission is not known without other forms of communication.

Talking With (TW) Students

Using related words, these three studies discuss teacher engagement in elicitation, in cumulative talk, or in exploring similarities and differences of ideas. These descriptions are most closely aligned to talking with (TW) students about their ideas. Nystrand et al. (2003) also described this as a “dialogic bid” (p. 151) where the teacher asks students to articulate their own points of view. The teacher takes up ideas, observations, and evaluations that the students introduce to encourage a range of student thought and action. Students are treated as having knowledge and opinions, even if these thoughts are “half-formed or simply flawed” (Newton, Driver, & Osborne, 1999, p. 367). The teacher’s mode of operation is “low interanimation” (Mortimer, Scott, & Aguiar, 2006, p. 611) where there is mainly listening or summarizing views and ideas from many students so that the class is aware of aired ideas (Simon, Erduran, Osborne, 2006). In a study by Nystrand et al. (2003) they found that this type classroom talk activity had a cumulative effect on fostering dialogic interaction.

Thinking Through (TH) with Students

These three studies discuss teacher engagement in reconstructive recaps, exploratory talk, and high levels of interanimation of ideas. These descriptions are most closely aligned to thinking through (TH) ideas with students. These can also be thought of as "guided discussions" (VanZee et al., 2001 p. 161) where aired ideas are thought through not only from the students' own ideas but through further restatements of ideas and explorations of ideas, then move toward more scientific ways of expressing thoughts by the teacher. Through high levels of interanimation of ideas, utterances from self and others become "a thinking device" (Bakhtin, 1986) (also see Osborne, 2007; Scott, 1998; Wells & Mejía 2005; Wertsch, 1991) that contributes to knowledge construction. The teacher uses student thinking to help "tune" student thinking about the concept in ways that the student might never have thought of (von Aufschnaiter et al., 2008; Mayer, Akamatsu, & Stewart, 2002). New ways of thinking are made possible because shared ideas from both students, teacher, and science are open for inspection, justification, and critique (Simon, Erduran, & Osborne, 2002). TH provides structure to help students move beyond their present level of thinking because it operates within the zone of proximal development (Vygotsky, 1986). In TH episodes with students the teacher's focus shifts from "listening to" students (characteristic of TW) to "listening for" (Deneroff, Sandoval, & Franke, 2002, p.13) the ways in which students' ideas are changing toward more literate talk (Boyd & Rubin, 2006). Meaning is negotiated during this whole-class class dialogue in what Newman et al. (1989) calls the "construction zone" which they say is "a magic place where minds meet, where things are not the same to all who see them, where meanings are fluid, and where one person's construal may preempt another's" (p. ix).

Patterns of Talk as a Lens for Analysis

These three conceptualizations of talking to (TT), talking with (TW), and thinking through (TH) used by a teacher are claimed as patterns of teacher talk later in this study. This researcher's position is that Edwards and Mercer (1987), Mercer (1996), and Mortimer and Scott (2003) ways of interpreting classroom dialogue involving the classroom talk reflected a restricted view of the classroom dialogue reported later in this study. However, the TT and TW pattern were largely inspired by analysis and its modest support from the literature. TT most aligned to elements of authoritative/non-interactive and disputational talk while TW accounts for expressions of students' ideas into classroom dialogue in ways not clearly articulated or discussed as distinct form of dialogue by these authors. In the case of TH, this pattern separates and highlights the reasoning and construction of already aired ideas and re-envisioned ideas that "tune" the classroom's shared understanding. TH is more than just dialogic/interactive and/or exploratory talk. TH ideas with students give the authority to the classroom's negotiated exploration into its experimental data, evidence, and understanding of expert thinking by scientists.

Critique and Consensus Making in Science Argumentation

Michael Ford (2008) in this article, *Redefining Disciplinary Learning in Classroom Contexts* has the thesis that in learning situations there is an overemphasis on knowledge construction without sufficient attention to critique of knowledge claims. He states:

> It is clearly important for students to understand something about the architecture of scientific knowledge. In science as a social practice, critique motivates authentic construction of knowledge that is uniquely scientific. Similarly in individual learning, authentic construction of knowledge may not be possible without a grasp of disciplinary critique...a *grasp of scientific practice*, its key reasoning patterns, and an awareness of the architecture of knowledge these produce can be crucial resources in learning novel scientific ideas with understanding. (Ford, 2008, p.405, italics added)

He later adds, "Scientists who are successful are so because they learn how to critique their own knowledge claims as their peers do" (Ford, 2008, p. 415). Teaching with sufficient attention to Ford's notion of "grasp of practice" is less about constructing a claim than the ways in which to critique it (Ford, 2008, p. 419). In Greek the word critique means a "lifting and separating of an object in order to examine its properties" (Fuenmayor, 1990, p. 526). In everyday language it often is talked about as revealing a negative feature of something (Fuenmayor, 1990). In the particular case of science, Ford (2008) in talking about critique says, "Each individual scientist is trying to construct his or her own explicit connection to nature's behavior. His or her peers are trying to find errors with it, that is, to critique the knowledge claim and its explicit connection to nature's behavior" (Ford, 2008. p. 409). The inevitable differences between one's constructed knowledge, the critiques of that same knowledge, and nature's behavior causes awareness of difference. These differences provide that magic place (Newman et al., 1989) where scientific negotiation happens to create a shared understanding. As negotiation progresses, "the community as a whole comes to a consensus regarding the account that explains most and conforms best to nature's behavior, which is how individual scientists' claims become the community's scientific claims" (Ford & Forman, 2006, p. 15). Critique then is a core practice of science and without it, reliable knowledge construction would not be possible (Osborne, 2010).

Kuhn and Reiser (2004) suggests that consensus making in science argumentation may assist in making ideas seem sensible. They further suggest that consensus making is a persuasive discourse that allows critiques to be received, debated, and revised. In this way, consensus activity can be thought of as a reasoning activity that helps to foster knowledge construction of ideas when the community agrees and disagrees with its own claims, evidence, and critiques. Students, however, struggle with providing constructive critique and when given a critique they struggle with counter explanation and/or clarification of ideas (Berland & Reiser, 2009). Sampson and Clark (2009) found that when students disagreed and could critique, they were more able to critically examine the claim and reasoning behind it. In a later work by Sampson and Clark (2011) they found that oppositional comments that included disagreements, critiques, and requests for justification helped to challenge the merits of idea. They claimed that it stimulated "a more in-depth conversation or the critical analysis of the merits of the idea" (Sampson & Clark, 2011, p. 83).

Meyer and Woodruff's (1997) research examined consensus making in a middle school science classroom in both small-groups and whole-class situations. They proposed three mechanisms within the consensus-building process: mutual knowledge, convergence, and coherency. *Mutual knowledge* is the group's effort to find common ground at the beginning of inquiry discourse by finding out what each already knows. When some understandings are revealed which are not mutually understood, tension arises within the group. *Convergence* is the process where by group members try to add to their mutual knowledge through inquiry and dialogue. Lastly, *coherency* is a process of linking ideas through interactions of small and large group experiences.

In summary, critique and consensus both serve as related and significant types of sense-making tools for the construction of scientific knowledge. Learning to critique in science argumentation means learning the architecture behind "grasp the practice" for the community of science (Ford, 2008). In this study, the practices of consensus-making in relation to critique were explored. By looking at consensus-making across time, it was hoped that one could glean how a classroom uses this critical element of science argumentation that works towards establishing a grasp of science practice (Ford, 2008). Learning to engage in consensus-making in science argumentation means that one's own constructed knowledge from experience, inquiry, and critique is shaped by coherently converging shared understandings (Meyer & Woodruff, 1997).

The Science Writing Heuristic (SWH) Approach

The science writing heuristic (SWH) is a writing-to-learn approach (Keys et al., 1999) that helps a science classroom community to embed science argumentation as a core component of their inquiry experience. The use of the SWH for inquiry investigations "help students participate in science disciplines in ways that resemble the thoughtful methods employed by 'real' scientists" (Hand, 2008, p. 2). The written work embedded within the approach is critical because without language (text) the social practices of science would not be possible (Hand, 2008, Norris & Phillips, 2003).

Table 2.2 The Two Templates for the SWH: The Teacher Template and the Student Template

Teacher Template: Activities to promote laboratory understanding.	Student Template
1. Exploration of pre-instruction understanding through individual or group concept mapping or working through a computer simulation.	1. Beginning ideas - What are my questions?
2. Pre-laboratory activities, including informal writing, making observations, brainstorming, and posing questions.	2. Tests - What did I do?
3. Participation in laboratory activity.	3. Observations - What did I see?
4. Negotiation phase I - writing personal meanings for laboratory activity. (For example, writing journals.)	4. Claims - What can I claim?
5. Negotiation phase II - sharing and comparing data interpretations in small groups. (For example, making a graph based on data contributed by all students in the class.)	5. Evidence - How do I know? Why am I making these claims?
6. Negotiation phase III - comparing science ideas to textbooks for other printed resources. (For example, writing group notes in response to focus questions.)	6. Reading - How do my ideas compare with other ideas?
7. Negotiation phase IV - individual reflection and writing. (For example, creating a presentation such as a poster or report for a larger audience.)	7. Reflection - How have my ideas changed?
8. Exploration of post-instruction understanding through concept mapping, group discussion, or writing a clear explanation.	8. Writing ≠ What is the best explanation that explains what I have learned?

Source: Hand, B. (2008). Introducing the science writing heuristic approach. In B. Hand (Ed.), *Science inquiry, argument and language: A case for the science writing heuristic*. Rotterdam, The Netherlands: Sense Publishers.

The SWH approach consists of a framework to guide classroom activity and provides metacognitive support for elements of argumentation (see Table 2.2). Within the framework, opportunities for knowledge construction happen through repeated scaffolds that assist students in rethinking and re-expressing in language their ideas. In every part of the SWH approach, some "grasp of practice" (Ford, 2008) is present, thus showcasing the ways in which the SWH approach does not separate learning argumentation from learning science. Clearly the approach strengthens the use of written language in science. However, the framework provides opportunity to whole-class dialogue as well. Both of these language experiences should be seen as interwoven and integral to the approach and student learning (Hand, 2008). Hand (2008) also describes the nature of the discussion when the SWH approach is used:

> The SWH is designed to promote classroom discussion where students' personal explanations and observations are tested against the perceptions and contributions of the broader group. Learners are encouraged to make explicit and defensible connections between questions, observations data, claims, and evidence. When students state a claim for an investigation, they are expected to describe a pattern, make a generalization, state a relationship, or construct an explanation (Hand, 2008, p. 7).

Several researchers have examined the SWH and have found that it supports elements and outcomes of science argumentation. In a study by Choi, Notebaert, Diaz, and Hand (2010) their results suggest that the SWH approach assists students in developing reasonable arguments. Erkola, Kışoğlub, and Büyükkasapc (2010) and Keys et al. (1999) found that student's conceptual understanding improved, while Martin and Hand (2009) found that students began to embed terms such as claims and evidence into their language exchanges in a SWH classroom. Benus, Yarker, Hand, and Norton-Meier (2011) found that classrooms having a high level of SWH implementation were more dialogic. Additionally, teachers who utilize the SWH approach described their experiences in an edited book, *Voices From the Classroom: Elementary Teacher's Experience with Argument-based Inquiry* (Hand & Norton-Meier, 2011). They discuss how they assist students in developing testable and researchable questions, making observations and claims, generating evidence, while all the time negotiating meaning through writing and talking.

For this study, a teacher was chosen who had experience with SWH. Research on the SWH approach provided ample support that students through embedded practice engage in argument-based inquiry that is principally dialogic, supports conceptual understanding, uses evidence, encourages classroom discussion, and uses patterns of language consistent with science argumentation.

Theoretical Framework of the Study

We learn in and through our use of language (Vygotsky, 1986). The patterns of talk that are produced through social interaction ultimately shape what and how we learn. Boyd and Rubin (2006) in their review of student talk in the classroom say, "Theory, research, and practice all converge on the conclusion that engaged, elaborated student talk in the classroom enhances student learning. Such articulate student talk supports inquiry, collaborative learning, high-level thinking, and making knowledge personally meaningful (see, e.g., Hynds & Rubin, 1990; Johnson, 1995; Nystrand, 1997; Wilkinson, Murphy, & Soter, 2005)" (Boyd & Rubin, 2006, p. 142). A dialogic approach to teaching and learning has its foundations in social constructivism and in particular Vygotsky (1986), Wells, (1999), and Wertsch (1985). Constructivist theory says that meaningful learning happens through interactions among individuals, and that repeated interactions over time help individuals to regulate their own behavior in and through their community of practice. It is through talk and dialogue that students' interactions are mediated. It is also one of the ways that students learn to make sense of their own world (Wells, 1999; Wertsch, 1985). Participating in a discourse practice, like science argumentation, means assuming a role within that community of practice (Wenger, 1993). The teacher also plays a key role in fostering dialogue in science argumentation. The teacher inculturates students into authentic practices through inquiry and social interaction, thus providing a type of cognitive apprenticeship (Brown, Collins, & Duguid, 1989). The students engaged with science argumentation engage in what Lave and Wenger (1991) call legitimate peripheral participation (LPP) (one aspect of situated learning), where students new to the practice of science argumentation become acquainted over time with the ways in which knowledge in and from inquiry is organized, explained, and critiqued. They move from newcomers to more mainstream practice where expert modeling and coaching by the teacher fades over time. In all these ways, the students and teacher move constantly back and forth from social (listening, talking, reading, and writing) to private ways (thinking and reflecting) of interacting with the inquiry process. In this way, students and teacher are constructing knowledge through interactions within the social environment of the classroom. In all these related and intermeshing ways this study is guided by an interactive-constructivist framework.

Interactive-Constructivist Framework

The interactive-constructivist framework has its early roots in work by Henriques (1997) and was later described by Yore (2001). Interactive constructivism can be thought of as a middle-of-the-road interpretation of constructivism (see Table 2.3). Yore (2001) explains that interactive constructivism, "recognizes that contemporary science is based on a hybrid worldview of knowing that stresses the importance of interactions with the physical world and the sociocultural context in which interpretations of these experiences reflect the lived experiences and cultural beliefs of the knowers (Prawat & Floden, 1994)" (Yore, 2001 p. 4). Interactive-constructivist perspective accounts for the limitations that learners have in the ways in which they are able to interpret the physical world. In this perspective all knowledge claims should be valued and evaluated on the merits of the ways in which the evidence in support of these claims holds up to the way that nature behaves. Construction of knowledge in this perspective moves back and forth in public and private ways, private in that understanding is unique to that individual (radical constructivism), and public in the ways which understanding happens through group negotiation processes such as consensus-making and critique (social constructivism). Dialogue around consensus-making happens when presented evidence is understood against nature, and often opens up varied ways of knowing, thus making consensus as "right" or "wrong" far less importance than multiple ways of knowing. The students and the teacher share learning opportunities in this perspective. Dialogic interactions can be as follows: the teacher talking to students; students in their own reflective inner thoughts; and most often, two-way, where the teacher talks with students or helps students in thinking through their ideas. The teacher in this perspective uses professional wisdom, supports "big ideas", and engages in varying forms of instruction and inquiry (Henriques, 1997, p.22; Yore 2001, p. 4).

Table 2.3 Four Faces of Constructivism

Feature	Information Processing	Interactive-Constructivist	Social Constructivist	Radical Constructivist
Worldview	Mechanistic	Hybrid	Contextualistic	Organistic
Ontological View	Realist	Naive Realist	Idealist	Idealist
Epistemic View	Absolutist (traditional)	Evaluativist (modern)	Evaluativist (postmodern)	Relativist (postmodern)
Judgment Criteria	Nature as Judge	Nature as Judge	Social Agreement as Judge	Self as Judge
Psychological Locus of Mental Activity	Private	Public and Private	Public	Private
Pedagogical Structure	Teacher	Shared: Teacher and Individuals	Group	Individual
Linguistic Discourse	One-Way: Teacher to Student	Two-Way: Negotiations to Surface Alternatives and to Clarify	Two-Way: Leading to Consensus	One-Way: Individual to Self (inner speech)

Source: Yore, L.D. (2001). What is meant by constructivist science teaching and will the science education community stay the course for meaningful reform? *Electronic Journal of Science Education, 5*(4). Retrieved on July 11, 2011 from http://ejse.southwestern.edu/article/viewArticle/7662/5429

Conceptual Framework for This Study

Science argumentation and dialogical interaction are well-paired approaches to learning. In science and in dialogue, more sophisticated understanding develops through engaged social experiences where contributions by all are valued. The teacher is the instrument that affords students the chance to practice argumentation, and the one person (likely the primary one) who stands in as a quasi member of the scientific community, having proficiency in "grasp of practice" of scientific argumentation. It is the teacher who ultimately must intervene to foster productive dialogues (Duschl, Schweingruber, & Shouse, 2007), because without teacher intervention, students do not spontaneously adopt productive dialogic discourse in science (Osborne et al., 2001). It is important, if not imperative, that teachers proficient in scientific argumentation be studied during their practice (Erduran, Ardac, Yakmaci-Guzel, 2006) if we hope to make this a core practice of school science practice.

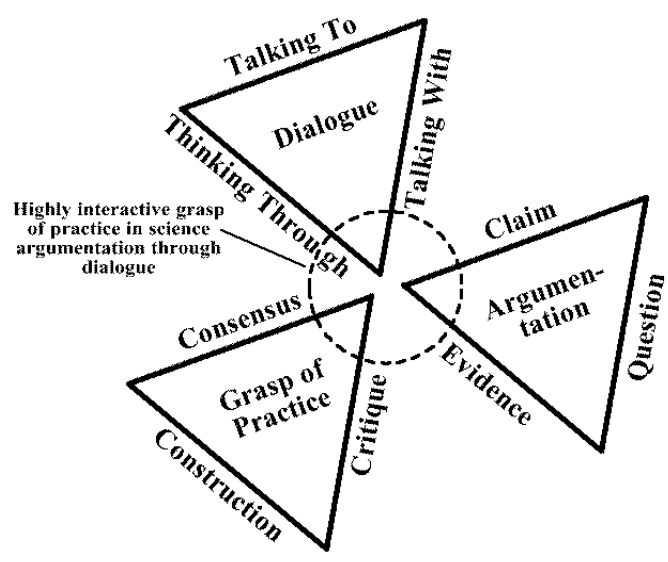

Figure 2.1 Conceptual framework for this study

Figure 2.1 represents this researcher's visualization of the conceptual framework for this study in the ways in which dialogue, argumentation, and grasp of practice interact in whole-class dialogue in science argumentation. Whole-class dialogue is primarily thought to occur with students and teacher; however, provided students have sufficient skills, whole-class dialogue without the teacher could still be represented in this framework. The teacher and students in this framework become more interactive in science argumentation when they move toward the center of three triads. When nearest the epicenter of this framework, whole-class dialogue is focused on the teacher talking with (TW) and thinking through (TH) group negotiation that includes consensus-making and critique around students' claims and evidence. The center is the place where all potentially in the class interact to construct a shared understanding. The elements of "talking to," initial "questions," and "construction" outline the framework, not to suggest they are unimportant but to emphasize that these are individualistic conceptions within dialogue, argumentation, and grasp of practice. That is to say, a question asked, a constructed idea, or a talking to episode is an individual construction and only can lead to science argumentation if it is acted on by and through other elements in each triad. Thus, TW, TH, consensus, critique, claims, and evidence are primarily socially driven elements in that claims and evidence are made to be critiqued and agreed upon through talking and thinking through ideas with others.

The design and data collected for this study focus on following the ways in which the teacher interacted to develop whole-class dialogue in the science classroom where argument-based inquiry was occurring so students could begin to have a grasp of what it meant to practice science. Analysis focused on understanding the teacher's interactions in science argumentation around dialogue with students as the classroom community constructed a grasp of practice through consensus and critique.

Summary

In this chapter, the researcher has presented existing literature that explains and supports the use of whole-class dialogue, science argumentation, and grasp of science practice as well as the theoretical and conceptual framework that grounds this study. It is well noted in the literature that a teacher's ability to engage the science classroom in productive dialogues in argument-based inquiry is a skill that takes time to develop for both teachers and students. The present literature base for science argumentation offers little insight on the ways in which a teacher initially develops whole-class dialogue from start of the school year with students who have no prior experience with argument-based inquiry. Additionally, the research on whole-class dialogue in science classrooms using argument-based inquiry is also very limited and fragmented, and exists only within studies that have other research foci. Finally, data collection and analysis used interactive constructivism as a framework, because in science argumentation, dialogue, and grasp of science practice, meaning is negotiated through shared interactions that bring into light private understanding that can be critiqued, reworked, and/or agreed/disagreed within the reach of the ways in which the community of science presently understands nature.

CHAPTER THREE

METHODS

In this chapter the researcher will establish the methodological framework for this study. This chapter first discusses why a qualitative approach was used. Then the context for the study will be described. Types of data collected, the data analysis procedure, and trustworthiness, of the study are also discussed.

Research Design

This study included two research questions: (1) What were the initial whole-class dialogue patterns established by a fifth-grade science teacher who engaged in argument-based inquiry (ABI)? (2) In what ways did the science teacher help to refine whole-class dialogue to support the agreeability of ideas constructed over time? In order to answer each research question a "basic qualitative approach" was used (Merriam, 1998, p.11). This approach to analysis was used to delineate a process or identify "recurrent patterns in the form of themes or categories" (Merriam, 1998, p. 12). Both research questions are best understood by looking at the ways in which patterns of teacher talk change over time. For the first research question, the researcher looked for patterns or types of whole-class dialogue that the teacher uses to establish dialogue over the 18 weeks of the study. The second research question examined over this same time period the process and pattern for the ways in which the teacher supported agreeability of ideas over time.

Research Context

School

The study was conducted in a fifth-grade science classroom taught by one white male teacher who teaches in a small city of less than 15,000 in the Midwestern United States. This classroom is one of five fifth-grade classrooms in an upper-elementary school that includes grades four through six. The school's population is approximately

94% white. About 16% of the students are eligible for free or reduced lunches. Approximately 525 students attend this school, and the district has approximately 2200 students (Information was obtained from school district website).

Classroom and Students

The classroom was situated midway down the fifth-grade hall corridor. Square-shaped, the room had one exit located midway along the left wall. On the left side was a drinking fountain and sink, ten feet of counter space, and a walled cabinet. There was a large white board in the front of classroom and to the left of this was a large screen that displayed information from the video copy stand and other multimedia. To the left of the white board was a station of six computers. The teacher's desk was in front of the room to the far right, along with a wall-mounted TV. The students' desks had large flat square tops, with children sized (14") royal blue chairs that rested on a lighter blue carpet. Throughout the study the desks were usually arranged in groups of 4-6. The florescent lights in the room were usually lit and the window with built-in blinds provided additional light for the room when needed. The classroom did not have air conditioning during the summer months and was heated in winter by a large radiator below the picture window on the right side wall. Bookshelves below a counter-top were along the right lower wall and there was additional space available above the countertop to place students' work on display. In the back of the classroom, on the right hand side, students had their own storage bins and accessed them before or after class. On the back wall was a chalkboard that was used mostly to display student generated work samples.

Twenty-one students were in this class, 11 males and 10 females of those students 18 were white, 2 Asian, and 1 black. These students were in this classroom for homeroom, silent reading, science, and mathematics. Science instruction took place everyday, unless there was a shorter school day or a scheduling conflict. This class also had their science instruction split into two time segments everyday. Science was the first academic subject of each day, with a time segment of 15 minutes. Following this, students went to either music, gym, or art, then came back for 15 minutes of silent reading, after which science resumed for 40 minutes. Students then went to recess, and then to the next teacher. After lunch they would return for mathematics instruction and end their day in this class before going home.

The Teacher

The teacher in this study was 32 years of age, held a Bachelor's degree in education, and was in his tenth year of teaching. He taught special education for three years and had spent the last seven years teaching fifth-grade. At the time of this study his teaching schedule consisted primarily of teaching science and math to two sets of fifth-grade students. One set of students was his homeroom class; he spent about two-thirds of the day with them. This study examined this teacher only in his homeroom science class.

Since the summer of 2007 this teacher had been involved with four summer professional development workshops that have encouraged the use of argument-based inquiry for science instruction. These professional development workshops used the approach of the science writing heuristic (SWH) (Hand, 2008; Keys et al., 1999) to help promote student-centered approaches to learning. The approach "helps students participate in science disciplines in ways that resemble the thoughtful methods employed by 'real' scientists" (Hand, 2008, p. 2). The workshops consisted of five principle features; conversations about aligning one's teaching practice with learning theory, taking part in a SWH lesson to experience the elements as a student would, looking at the role of language in learning science, practical and pedagogical issues related to implementation, and helping teachers design an instructional unit around a "big idea" in science that follows the SWH approach.

During each academic year, the teacher in the study received onsite and off-site professional development and support where elements emphasized in the workshop were discussed in the context of his actual classroom practice. He was required to submit one classroom video per year to researchers involved with the professional development project. These videos were examined and used to provide targeted professional development of his practice using the SWH approach.

Videos from previous research projects of the teacher in this study were scored using a modified version (see Table 3.1) of the Reformed Teaching Observation Protocol (RTOP) (Martin & Hand, 2009). RTOP (Piburn et al., 2000; Sawada et al., 2002) is an observational instrument designed to measure "reformed" teaching. The original RTOP consists of 25 Likert-type scales in five subscales (lesson design and implementation, propositional knowledge, procedural knowledge, communicative interactions, and student/teacher relationships). The reliability of RTOP was tested by inter-rater reliability (i.e., $r^2 = .954$, $p < .01$) and internal consistency (i.e., Cronbach's $\alpha = .97$) (Sawada et al. 2002). The authors of RTOP describe it as consistent with the nature of scientific inquiry (AAAS, 1989). They further reference in their alignment the National Science Education Standards (NRC, 1996) noting that in reformed classrooms "students explain and justify their work to themselves and to one another" (NRC, 1996, pg. 33).

The modified protocol consists of a subset of thirteen of the original twenty-five items. Similar to the unmodified protocol, each item ranges from zero (never occurring in the class) to four (very descriptive for the class). The modified protocol consisted of four subscales (teacher questioning, teacher role, student voice, and science argument) that closely align to the SWH as one approach to argument-based inquiry. Martin and Hand (2009) describe this alignment with the thirteen items to elements of the SWH (see Table 3.1). Studies by Cavagnetto, Hand, and Norton-Meier (2010) and Martin and Hand (2009) have shown there was a relationship between higher modified RTOP scores and the teacher's level of implementation of the SWH. The SWH approach emphasized the teacher's role in establishing patterns of questioning and interactions that aid students in developing their own ideas by giving students a voice to negotiate meaning through questions, claims, and evidence (Hand, 2008). Given that an RTOP score was determined based on classroom talk and actions either through watching a video or onsite visit, a high RTOP score would indicate that there were sufficient instances of dialogic interaction. Table 3.1 is taken from Martin and Hand's (2009) paper, and provides a comparison of RTOP subscale indicators and corresponding SWH categories.

Table 3.1 Comparison of Modified RTOP and SWH Categories

RTOP	SWH
Student voice	
1. Instructional strategies respected students' prior knowledge/ preconceptions.	**Connections:** There is an emphasis on determining student knowledge and building teacher plans based on this knowledge.
5. Focus and direction of lesson determined by ideas from students.	**Connections:** Teacher builds or activates students' prior knowledge with some evidence of using it to make instructional decisions.
16. Students communicated their ideas to others.	**Focus on learning:** Student sharing with argumentation/connections in either small group, group to group or whole group.
	Connections: Language activities flow naturally throughout the SWH.
	Science argument: Teacher promotes linkages to big ideas and begins to promote debate on these ideas.
18. High proportion of student talk and a significant amount was student to student.	**Focus on learning:** Student sharing with argumentation/connections in either small group, group to group or whole group.
	Dialogical interaction: Communication effectively varies from teacher to student and from student to student according to the situation.
19. Students' questions and comments determined focus and direction of classroom discourse.	**Connections:** Teacher effectively builds or activates student prior knowledge with evidence of using this to make instructional decisions.
	Dialogical interaction: Teacher is not compelled to give right answer shifting focus to the big idea. Teacher uses all levels of questioning, and adjusts levels to individual students.
Teacher role	
24. Teacher acted as resource person, supporting and enhancing student investigations.	**Focus on learning:** Teacher effectively plans for teacher and student instruction as needed and appropriate.

Table 3.1 Continued

25. The metaphor "teacher as listener" was very characteristic of this classroom.	**Dialogical interaction:** Teacher used questions to explore student thinking. Teacher's response to student answers is probing, connects, and extends, questions.
Science argument	
13. Students were actively engaged in thought provoking activities that involved critical assessment of procedures.	**Connections:** Science activities promote big ideas clearly and extend students learning. Connections can be seen from beginning to end and are articulated by students.
14. Students were reflective about their learning.	**Science argumentation:** Teacher demands connections between question, claims, evidence and reflection.
15. Intellectual rigor, constructive criticism, and the challenging of ideas was valued.	**Focus on learning:** Student sharing with argumentation/connection in small groups, group to group and whole group with few prompts. **Science argumentation:** Teacher promotes linkage to big ideas and promotes debate on these ideas.
21. Active participation was encouraged and valued.	**Science argument:** Teacher requires students to link claims and evidence. Teacher scaffolds questions, claims, evidence and reflection. Promotes linkages to big ideas, and promotes debate of these ideas.
22. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	**Science argumentation:** Teacher scaffolds questions, claims, evidence and reflection. Promotes reflection to big ideas and promotes debate of these ideas.
Questioning	
17. Teacher questioning triggered divergent modes of thinking.	**Dialogical interaction:** Students are asked to explain and challenge each others' responses rather than the teacher passing judgment. Teacher asks many layered questions (i.e. Bloom's Taxonomy). Teacher is not compelled to give "right" answer shifting focus to the big idea.

Source: Martin, A. M. & Hand, B. (2009). Factors affecting the implementation of argument in the elementary science classroom. A longitudinal case study. Research in Science Education. 39(1), 17--38.

RTOP scores of the teacher in this study (see Table 3.2) indicated that he focused and supported "inquiries while interacting with students," orchestrated "discourse among students about scientific ideas," recognized and responded "to student diversity," and encouraged "all students to participate fully in science learning." Lastly, this teacher also "model[ed] the skills of scientific inquiry" (NRC, 1996, p. 32).

Table 3.2 Modified RTOP Scores for Participant's Classroom

		Modified RTOP score			
#	Descriptor	2007-2008 School Year	2008-2009 School Year	Fall 2010 School Year	Spring 2011 School Year
	Student Voice				
1	The instructional strategies and activities respected students' prior knowledge and the preconceived notions inherent therein.	4	3	3	3
5	The focus and direction of the lesson was often determined by ideas originating with students.	3	3	3	4
16	Students were involved in the communication of their ideas to others using a variety of means and media.	3	3	3	3
18	There was a high proportion of student talk and a significant amount occurred between and among students.	4	4	4	4
19	Student questions and comments often determined the focus and direction of classroom discourse.	3	3	4	4
	Teacher Role				
24	The teacher acted as a resource person, working to support and enhance student investigations.	3	3	3	3
25	The metaphor "teacher as listener" was very characteristic of this classroom.	4	3	4	4
	Science Argument				
13	Students were actively engaged in thought provoking activity that often involved the critical assessment of procedures.	3	3	3	3
14	Students were reflective about their learning.	3	3	2	3
15	Intellectual rigor, constructive criticism and the challenging of ideas were valued.	3	3	3	4
21	Active participation by students was encouraged and valued.	4	4	3	3
22	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	3	3	3	3
	Questioning				
17	The teacher's questions triggered divergent modes of thinking.	2	2	3	3
	TOTAL (Full score = 54)	45	43	41	44

Over the last four years this researcher worked on other research projects involving this teacher, and historical modified RTOP scores were available for this teacher's classroom from the middle of the 2007-2008 and the 2008-2009 school year. Additionally, two videos were scored from this present study representing the approximate midpoint of the school year. These videos were taken from the middle and end of the second unit of instruction that roughly corresponds to the middle of the school year in the 2007-2008 and 2008-2009 videos. A scorer with over four years of experience using the modified protocol scored all videos. The highest possible score on the modified RTOP was 54 points. A low rank was 25/54, medium rank was 26-39/54, and high rank was 40-54/54. These rankings corresponded to an average score of less than two for low rank, more than two but less than three for medium rank, and higher than three for high rank. The teacher's scores ranged from 41-45 that indicated that the teacher had a high level of reformed-based practice. Table 3.2 shows the Modified RTOP values for each of the indicators.

Through these four summers of professional development, on-site and off-site ongoing professional development, and consistent high ratings of reformed-based practice using the SWH approach, it was reasonable to assert that this teacher was sufficiently experienced in implementing the SWH approach as one approach to argument-based inquiry. Based on this assertion this teacher was asked to participate in the study in anticipation that he possessed sufficient dialogical and pedagogical skills to aid students in developing their own ideas through the use of ABI.

Two Instructional Units

During the course of the first 18 weeks of the school year the students completed a short, one week mini-unit in which they examined a murder mystery (Norton-Meier, Hand, Hockenberry, & Wise, 2008; Rudd, J., 2009) by making claims and trying to support it with evidence. The students were given a blue mystery tube and asked to make a claim about the way in which that system works, and to the claim them with evidence. The teacher worked with students in making a claim and the methods they might use to support this claim. This pre-unit lasted six days and served as an early introduction to ABI. The first unit's big idea was "Living things and their environment affect each other;" this unit lasted eight weeks. The second unit's big idea was "human body systems work together;" this unit lasted 9 weeks. In each of the units there were the typical breaks in instruction due to scheduled holidays, canceling of school, teacher not in class, and other situations. However, science on 'normal' days lasted for about 55 minutes and the teacher always used the SWH approach. The starting date for video used in this study was August 25 and the ending date was January 18. These dates corresponded to the start of the pre-unit and the end of the second unit.

The two units were well aligned to building/district, state, and national science standards. The building/district standards were the same, since this was the only building in the district where fifth-grade was taught. The standards of the district were the same as the content standards headings used in the 1996 National Science Education Standards (NRC, 1996). Wording of the standards also closely resembled the NSES. Additionally, these also aligned to this school's state standards for science. Table 3.3 shows this alignment of district standards to the two unit and the state standards. The state standards do not have detailed descriptions for Standards 1, 5, 6, and 7, other than having a paragraph that states that these should be integrated into the other standards.

For each unit of instruction, the fifth-grade science teachers in the school had identified their essential question, overarching idea, content, and skills for each unit. Table 3.4 is an abbreviated summary of the curriculum maps used in each unit for this study.

Table 3.3 Alignment of School District's Standards to the Two Units of Instruction and State Standards.

Fifth-grade Science Standards for District/School	Unit	State Standards
SCIENCE STANDARD 1: Science as Inquiry		
1A: Science as inquiry. Identify the steps of the scientific investigation Science	1, 2	√ (integrated)
SCIENCE STANDARD 2: Physical Science		
2C: Interactions of energy and matter. Identify chemical and physical changes in the body	2	√
SCIENCE STANDARD 3: Life Science		
3A: Characteristics of organisms. Student will identify the basic organs and functions: digestive, circulatory, and respiratory	2	√
3B: Interactions of organisms and their environment. Understand the interaction of living things with their ecosystems	1	√
SCIENCE STANDARD 4: Earth and Space.		
4B: Changes of earth and sky. Understand the causes of the Earth's seasons		√
SCIENCE STANDARD 5: Science & Technology		
5A: Understanding about science and technology. Understand how technology relates to space exploration & survival		√ (integrated)
SCIENCE STANDARD 6: Science in personal and social perspectives		
6A: Environmental quality. Understand how pollutants contribute to environmental conditions	1, 2	√ (integrated)
SCIENCE STANDARD 7: History and nature of science		
7A: Science as a human endeavor. Collect and analyze data as done by scientists	1, 2	√ (integrated)

Table 3.4 Curriculum Map for Science Unit 1 and Unit 2

Factor	Unit One	Unit Two
Essential Question (big idea)	Living things and their environment affect each other	Human body systems work together.
Overarching idea	Factors affect environmental balance. How do various factors affect environmental balance?	How do the human body systems interact with each other? How can we positively and negatively affect our body?
Content	An ecosystem is a community of organisms that can be categorized by the functions they serve in an ecosystem. Pollutants can affect the stability of an ecosystem; solutions can help minimize or alleviate the effects of pollutants.	Basic understanding of the circulatory, digestive, respiratory, immune, and nervous systems. Interactive nature of the circulatory, digestive, and respiratory systems.
Skills	Making and testing beginning ideas, communicating information through writing, drawing, and discussion. Applying previously learned information to analyze a problem and suggest solutions.	Using senses, data collecting, classifying, questioning, measuring, relating, distinguishing, inferring, experimenting, verifying claims/evidence, building models, making decisions, negotiation, drawing, modeling

Each unit started off with students being told the "big idea". After this happened, students were asked to create questions which they had about this big idea. After students proposed questions in writing they decided, with the help of the teacher during whole-class dialogue, if the questions were testable or researchable. The students then drafted ways in which they might test their questions, proposed their plan to classmates for review and critique, revised as needed, performed experiments, made claims with evidence from these experiments and researchable information, presented these ideas to classmates for review and critique, and revised and represented as needed. Along the way this activity entailed interaction in groups, whole-class conversation, note-taking, and journaling to reinforce the content and skills described on the curriculum maps.

Data Collection

Data were collected from several sources during the 18 week duration of the study, including classroom videos, non-participant observations, semi-structured interviews, informal conversations before and after selected lessons, and researcher's field notes. Overtime, these data sources helped to provide a more comprehensive perspective (Patton, 2001) regarding this teacher-developed classroom dialogue. These sources were all related over time, yet distinct in their own way, and helped with the triangulation of data (Stake, 1995). Table 3.5 provides a summary of the data type, data source, and purpose of the data collection.

Table 3.5 Data Type, Data Source, and Purpose for this Study

Data Type	Data Source	Purpose	Items Collected
Non-participant observation	Whole class	To access, on-site the ways in which the teacher helped students to establish whole-class dialogue and overall classroom interactions.	39 instances over the 18 weeks of the study.
Video	Whole class video of lessons	To access for further analysis the ways in which the teacher worked with students in establishing whole-class dialogue	84 days of science lessons over the 18 weeks of the study
Semi-structured interview	At the start of the school year.	To understand the teacher's approach to the ways in which he will work towards establishing whole-class dialogue with students over time.	One 40 minutes interview on first day that data was used for the study.
Informal conversation	After selected lessons when researcher is present	To understand how the teacher thought about elements of ABI across time.	29 instances usually after the lesson lasting 3-7 each time.
Field notes	Journal from classroom observations	To capture researcher thoughts from being in-person in the classroom and to help illustrate what videoing may not be able to capture.	39 entries from observation and reflection after visits

Non-Participant Observation and Video

The two units were observed over the course of 18 weeks through non-participant observations. This method allowed the researcher to see and hear all aspects of classroom life. This included teacher and student interactions and student-to-student interactions during all classroom activities. These activities included, but were not limited to, the eight aspects of the SWH approach (Hand, 2008, p. 6) that include beginning ideas, tests, observations, claims, evidence, reading, reflection, and writing. It was not possible for the researcher to be present for every lesson. However, a total of 39 non-participant observations were made across the 18 weeks of this study. Video recordings also occurred during every non-participant observation as well as times when the researcher was not present, because the teacher willingly started and stopped the video recorder in this researcher's absence. A total of 84 days of science lessons were captured either by the researcher or the teacher. The digital camera was placed in the back of the classroom to capture most of the classroom activity. When the researcher was present the camera was sometimes adjusted to better capture events in the classroom. Overall, the video captured all talk from the teacher without difficulty. Depending on where students were sitting, how loudly they spoke, and/or who was talking over them largely determined the quality of recorded student talk.

Semi-structured Interviews and Informal Conversations

Interviewing is an important research tool in helping researchers to understand the research participant's point of view. Kahn and Cannell (1957) describe interviewing as a "conversation with a purpose" (P. 149) and Kvale (1996) describes the qualitative interview as "a construction site for knowledge" (p.7). A semi-structured interview, lasting 40 minutes, was conducted at the start of the study to find the ways in which the teacher explained elements of argument-based inquiry, and what methods he planned to use to implement argument-based inquiry during the school year. Informal conversations took place after and occasionally before twenty-nine observed lessons. Conversations usually lasted from 3-7 minutes and often took place in the back of the room where the researcher was sitting and recording during observations. These conversations centered on how the teacher perceived that he was helping to establish the norms of ABI. A particular focus, when applicable to the observation, was placed on asking how whole-class dialogue was progressing around critique and consensus-making. Some observed lessons had little or no whole-class dialogue because of group experimentation, group work, and individual writing. Interviews on those occasions were more general conversations about ABI in the teacher's science classroom. When recorded, these semi-structured and informal interviews were transcribed for further analysis. At other times notes after the conversation were taken.

Researcher's Field Notes

Field notes are used to record an observer's feeling and reactions to the research setting, and to record quotes and actions from participants (Patton, 2001). Field notes were recorded during each observation. These notes generally included the student and teacher utterances and noteworthy observations with the ways in which the teacher or students were acting or responding in particular episodes of dialogue. These field notes were typed and recorded on a laptop. Field notes also included reflections or summaries of classroom activity after a lesson had ended, and were usually written after leaving the classroom. The general framework for the field notes collected in this study focused on noting whole-class dialogue interactions and the ways in which consensus-making and critique were being discussed, if at all, during a particular lesson.

Data Analysis

The research questions of this study were: (1) What were the initial whole-class dialogue patterns established by a fifth-grade science teacher who engaged in Argument-based inquiry (ABI)? (2) In what ways did the science teacher help to refine whole-class dialogue to support the agreeability of ideas constructed over time? To answer the two research questions the constant comparative method (Strauss & Corbin, 1990) was used. In using this method, patterns within and across segments can be analyzed. Data were coded using predetermined codes, open coding, axial coding, and selective coding (Strauss & Corbin, 1990). Goulding (1999) described open coding as breaking down of data in units of analysis, and was one of the first processes that helped the data to be conceptualized and labeled. Axial coding helped to reassemble data that was fractured during open coding (Strauss & Corbin, 1990) and reduced the number of codes to show relationships among them. The reduction in subcategories also helps to increase the density of remaining categories. Finally, in selective coding relationships are strengthened and supported through looking for relationships with other data sources for further refinement and development (Strauss & Corbin, 1990).

This researcher developed a three-step analysis procedure for both research questions. For both research questions the analysis consists of: Level 1) identifying overall dialogue and activity types in each transcript; Level 2) identifying and comparing dialogue codes when teacher converses during only whole-class dialogue; Level 3:1) identifying patterns of teacher dialogue over time in whole-class conversations; and Level 4:1) analysis and comparing to other data sources. For the second research question analysis also included: Level 3.2) identifying instances of agreeability of ideas by teacher in whole-class conversations; Level 3.3) creating codes to identify types of agreeability; Level 3.4) comparison of codes in transcripts over each time segment; and Level 4.1) analysis and comparing to other data sources. Each step was summarized in Table 3.6 and will be discussed in greater detail below.

Table 3.6 Three-Step Analysis Procedure

Type of comparison	Analysis activities	Goal	Questions
First Step – To address either research question			
Level 1: Identifying overall dialogue & activity types in each video/transcript	Coding: Interpreting the initial patterns of all classroom activity.	Identify instances of whole-class dialogue	What was the nature of the activity in the room?
Level 2: Identifying and comparing dialogue codes when teacher converses during only whole-class	Axial coding: Shape the criteria of whole-class dialogue codes Selective coding: Testing the strength of dialogic form across time.	Identify forms of whole-class dialogue Understanding the forms of dialogue over time	What were similarities and differences among whole-class dialogue segments? Do some codes fade and/or strengthen over time?
Second Step – To address first research question			
Level 3:1 Identifying patterns of teacher dialogue over time in whole-class conversations	Categorizing: Determining patterns of whole-class dialogue over time.	Understanding the patterns of dialogue over time	What were similar, distinct or irregular, or shifts in patterns over time?
Level 4: Analysis and comparing to other data sources	Triangulating: Cross-checking how field notes, inter-views, & conversations support pattern	Consensus of pattern among other sources of data	What patterns were recognized from other data sources? What was a pattern that could be supported across all data sources?
Third Step – To address second research question			
Level 3.2: Identifying instances of agreeability of ideas by teacher in whole-class conversations	Open coding: Interpreting the initial instances of agreeability.	Identify instances of agreeability of idea in whole-class dialogue	What was the nature of the consensus activity in the room?
Level 3.3: Creating codes to identify types of agreeability	Axial coding: Shape the criteria of agreeability codes	Identify forms of agreeability	What were similarities and differences among agreeability codes?
Level 3.4: Comparison of codes in transcripts over each time segment	Selective coding: Testing the strength of agreeability across time.	Understanding the forms of agreeability over time	Do some codes fade and/or strengthen over time?
Level 4: Analysis and comparing to other data sources	Triangulating: Cross-checking how field notes, inter-views, & conversations support pattern	Consensus of pattern among other sources of data	What patterns were recognized from other data sources? What was a pattern that could be supported across all data sources?

Level One Analysis (for both research questions)

All the potential data for the study included 84 days worth of video. When this study was proposed the initial plan was to use 7-11 calendar days of video from the first, middle, and end for each of units plus the pre-unit. This represented 51 days of instruction. The videos were viewed and the type of activity was generally coded and time-marked in a spreadsheet. This time marking indicated the overall nature of the activity. Such notation included time of event, teacher talking to, teacher talking with, student only talking, teacher and students talking, group work, individual work, classroom movement, a short summary of the topic. If notation was whole-class talk it was noted as 'not transcribed'. Table 3.7 represents an example of this type of Level One coding for November 11, 2010 video. In this example the Talking with and Talking to episodes would be later transcribed. Small group would not be later transcribed because it was not whole-class dialogue. All other videos followed this similar format in this level of analysis.

Table 3.7 Example of Level One Coding

Date and Time	Classroom Activity
11-11-2010	
00:00 - 7:14	Talking with
	[test design discussion]
	[NOT TRANSCRIBED]
07:14 - 10:11	Small group work
	[test design discussion]
10:11 - 10:47	Talking to
	[what was the test going to look like?]
	[NOT TRANSCRIBED]
10:11 - 12:29	Small group work
	[test design discussion]

Level Two Analysis (for both research questions)

Level two analysis began after several pre-unit and beginning of first unit level one coding was completed. This process first involved transcribing the video with particular focus on what the teacher said during any episode of whole-class dialogue. All teacher talk was transcribed and if possible student talk was also transcribed. Each minute of video took this researcher approximately 6 minutes to transcribe. Student talk was difficult to transcribe because it was sometimes inaudible and/or students talked over each other, making any voice difficult to hear. This study was focused on the teacher, and every effort was made to capture every word spoken by the teacher in whole-class dialogue. Transcriptions were checked and revised against the video as needed throughout the coding process. As all analysis progressed, corrections in the transcriptions to the teacher's talk as spoken became infrequent.

Early in this level of analysis, forms of whole-class dialogue involving the teacher, once transcribed, were coded as "talking to", "talking with". These two codes were initially simple ways of differentiating when the teacher was giving information rather than talking with students in some initiate/response format. In pre-unit and beginning of the first unit segments, the talking with (TW) episodes had little range of difference. After transcribing video later in unit one and into unit two it became apparent that "talking with" did not capture some of the dialogic interaction that was helping students to construct and to understand of the unit's concepts. The code of thinking through (TH) was adopted to better capture some of the whole class dialogue. By the time this level of analysis was completed all codes were stable and represented all basic types of talk in the classroom. Table 3.8 represents the codebook with activity, code, and description.

Table 3.8 Codebook for Whole-Class Dialogue and Activity

Activity	Code	Description
Teacher **T**alking **T**o students	TT	*Teacher talking to* students for a turn of talk that lasted usually more than 5 seconds. All students were asked or expected to be listening to the teacher. If student talk did occur during these moments it was infrequent and very short.
Teacher **T**alking **W**ith students	TW	Teacher was *talking with* students over several turns of talk (usually more than 15 seconds) to help students express or explain their thoughts about a particular idea. The teacher was helping students to hear the ideas of their classmates. The teacher pointed out what was stated from student talk as well.
Teacher **TH**inking though ideas with students	TH	Teacher was *thinking through* ideas with students over several turns of talk (usually more than 15 seconds) to help students think through their understandings. The teacher mentioned ideas that might not have directly come from students or bring together ideas from the past that were mentioned by students.
Student only **T**alk	ST	*Student talking* to students over turns of talk that last usually more than 15 seconds. Students as a whole class talked to each other without the teacher talking.

Level Three Analysis (for the first research question)

When early level three analysis started, the transcripts for the middle of each unit were completed. The middle of the first unit was 11 calendar days, but involved eight actual teaching days and seven hours of instruction. The middle of the second unit was 10 calendar days, but involved six teaching days over five hours of instruction. These two differences in actual instructional time made interpretation of early analysis difficult. Because the pre-unit was approximately two-hundred minutes all other segments were reduced to approximately the beginning 200 minutes, middle 200 minutes, and ending 200 minutes in each unit. These segments represented either four or five days' worth of lessons due to variations in length of lesson (for example, unit one finished in the same class period as unit two started). The study, after this point in the research process, included 31 of the 84 days of lessons. Table 3.9 shows the dates and lengths for each segment.

Table 3.9 Videos for Analysis for Establishment of Whole-class Dialogue

Days	Minutes of Video	Date	Unit	Topic
4	192	08-25 / 08-30	Pre unit	Murder Mystery String System
4	206	09-01 / 09-07	First	Beginning: How do living things affect their environment
4	207	09-20 / 09-27	First	Middle: How do living things affect their environment
4	207	10-25 / 10-28	First	End: How do living things affect their environment
6	198	10-29 / 11-12	Second	Beginning: How does the human body system work
5	202	12-13 / 12-20	Second	Middle: How does the human body system work
4	200	01-13 / 01-18	Second	End: How does the human body system work

During this level of analysis the four whole-class dialogue patterns of TT, TW, TH, and ST were carefully looked at across time to see the ways in which they remained similar, irregular, or shifted as time went on. Teacher's words were timed and counted in each talk type to better see shifts in teacher talk as time went on. The time length of each pattern was also sought to understand how that shifted over time. Patterns of talk before and after student talk were also examined to see if shifts were occurring. Table 3.10 summarizes the nature of the level three analysis and the reasons for it.

Table 3.10 Level Three Analysis

Activity	Description	Reason
Words spoken by teacher	Count words spoken by teacher in all unit segments (TT, TW, and TH instances)	Better see shifts in teacher talk over time
Time spoken by teacher	Time and sum teacher talk in all unit segments (TT, TW, and TH instances)	Better see shifts in teacher talk over time
Time of each pattern	Length of time in each pattern (ST, TT, TW, TH) in each unit segment	Understand how certain patterns shift if any over time. Can also show percent shift.
Time spoken by students	Time and sum student talk in all unit segments (ST, TW, and TH instances)	Better see shifts in student talk over time
Patterns of talk before and after student talk	Note that other codes (TT, TH, TW) appear before or after ST pattern in all unit segments.	See shift in type of dialogue pattern if any over time

Level Four Analysis (for the first research question)

In this level of analysis, triangulation was used to provide a more detailed and balanced picture of the analysis (Altrichter et al., 2008). Transcribed interview data, ongoing conversations, and field-notes data were analyzed to gather further understanding of patterns of whole-class dialogue and the ways in which the teacher fostered dialogue over time. Four categories were used to capture these occurrences; (1) evidence for talk and reflection on developing dialogue, i.e., ideas about improving the ways that teacher and student and student to student dialogue might improve; (2) thinking with students, i.e., any response or idea on what the teacher was doing to develop ideas with students; (3) teacher voice, i.e., any ideas or response on the methods that the teacher used to build whole-class dialogue; (4) student talk, i.e., any ideas or response on the ways that students were using talk to support whole-class dialogue. This analysis was then mapped against the coded patterns of whole-class talk in the video transcripts to support an understanding of patterns in whole-class dialogue from the pre-unit to the end of the second unit. Table 3.11 summarizes the categories and provides examples of the coding used in this level of analysis.

Table 3.11 Codebook for Interview and Field Notes for Whole-class Dialogue Patterns

Categories	Description	Example
Developing Dialogue	Any response or idea related to improving the ways the teacher and student talked	"So we shifted from sitting and staring to all kinds of conversation, but now we have to shift that to…"
Thinking with students	Any response or idea on the ways that ideas were developed with students	"Part of it is chiming in and redirecting them. It's more of a redirection, change of direction, than 'this is what we're doing', 'this is where we're going'"
Teacher voice	Any ideas or response about the way that the teacher uses talked	"First unit, it's a lot of involvement, work on my part, working with them. Stopping lessons, or you know, things that are going on in class."
Student voice	Any ideas or response about the ways that students use talked	"Now they're also starting to do something with their own conversation, calling each other out. But that's also because we've been practicing and getting more people involved"

Second Research Question Analysis

The second research question dealt with the ways in which the science teacher helped to refine whole-class dialogue to support the agreeability of ideas constructed over time. This question was answered through coding and analysis of transcripts, interviews, conversation, and field notes. Agreeability can be thought of as forms of consensus and/or critique. Kuhn and Reiser (2005) suggest that consensus making in science argumentation is a persuasive discourse that allows critiques to be received, debated, and revised. Ford (2008) sees critique and consensus as related in that any one's critique is an attempt to see how harmonious one's ideas connect to the ways in which nature behaves, and how one's peers see errors with those same connections to nature. As these critiques are negotiated, the community of scientists try to reach consensus (harmony) on the ideas that "explains most and conforms best to nature's behavior" (Ford & Forman, 2006, p. 15). In analyzing for the second research question, teacher attempts to foster agreeability, consensus, and critique were considered. The level one and two analyses discussed earlier were also used for the second research question.

Level Three Analysis (for second research question)

In this level analysis the videos had already been transcribed and coded for types of whole-class dialogue. TT, TW, TH, ST episodes were analyzed to identify instances of agreeability of ideas by teacher in whole-class conversations. Although ST talk and student gestures were not coded it was used in helping to determine when the teacher was engaging students in moments of agreeability. It was an open coding process. However, agreeability in dialogue is about agreeing, disagreeing, yes, and no at its most basic level. Looking for these words and the ensuing dialogue around these ideas was the first open approach to coding the transcripts. This process yielded other words or phrases used by the teacher in attempts to help students agree/disagree. Those included words and phrases such as “can we”, “do you think”, “how many say”, “should we”, “consensus”, “decide”, “similar”, “different”, “same”, and “guessing”. All these words and phrases were marked, provided they were attempts at dialogue in support of agreeability with some idea, concept, and/or process. For example, “I will give you a little more time, I guess” would not have been coded while “How many guess it came like that?” is a call for agreeability.

The preliminary markings were then coded and grouped based on the function or way that the agreeing and disagreeing was used. The teacher asked individual students if they agreed/disagreed and also asked the whole class if they agreed/disagreed. Also, the teacher talked about past things already agreed upon, the need to support the reason for the agreement, and that students needed to reach agreement. Table 3.12 is the codebook with code, description, and examples.

Table 3.12 Codebook for Consensus Making in Whole-class Dialogue

Code	Description	Example
Ccs	Teacher asked class consensus of student idea	"how many say" "show of hands" , "yes/no"
Sad	Teacher recognized student agreeing/disagreeing	"x agreed so", "I heard", "you all agree", "I am hearing"
Sai	Teacher called on a student to hear agreeability of idea	"x do you agree?", "what do you think"
Tra	Teacher reminded students of their past consensus	"we said", 'you all said"
Sju	Teacher asked a student justification for agreement	"why do you agree", "why did..", because?"
Rsa	Teacher reminded students that class needs to reach consensus or agreement	"talk to them"
Tad	Teacher agreed or disagreed with student idea	"The part that I might agree with"

Level Four Analysis (for second research question)

In this level of analysis, triangulation was used to provide more support for the ways in which the teacher engaged students in consensus-making activity. Transcribed interview data, ongoing conversations, and field-notes data were analyzed to gather further understanding of the ways in which consensus making was occurring over time. Three categories were used to capture these occurrences; (1) agreeing/disagreeing, i.e., the manner in which the teacher talks about how agreeability is going in the class; (2) consensus, i.e., this was any response or idea related to how the teacher talks about consensus; (3) critique, i.e., this was any response that talked critique. This analysis was then mapped against the coded patterns of consensus-making in the video transcripts to support an understanding of consensus-making from the pre-unit to the end of the second unit. Table 3.13 shows the categories and provides examples of the coding for interview data and field notes.

Table 3.13 Codebook for Interview and Field Notes for Consensus-making and Critique

Categories	Description	Example
Agreeing / Disagreeing	Any response or idea related to the ways the teacher and students talked about agreeing or disagreeing with ideas	"A couple of the boys are starting to say 'I don't agree with how you have it phrased, can you say this' And that's what will happen as we start maturing with our language"
Consensus	Any response or idea related to the ways the teacher understood and talked about the consensus process	"It seems when there isn't consensus there is real frustration and that isn't fun for them"
Critique	Any response or idea that talked about critique during whole-class conversation	"They're telling why, so they're doing a form of critique...as they are adopting other peoples ideas and changing, they're really constructing...They're critiquing themselves as they do it as well."

Trustworthiness

Lincoln and Guba (2000) say the study's findings should be "sufficiently authentic" (p. 178) to the point where one may trust acting on the implications. The research should provide "a comprehensive, comprehensible picture" (Stake & Mabry, 1995, p. 303). Trustworthiness for this study was established through creditability, transferability, and dependability. Table 3.14 shows a summary of the ways in which these were achieved. A more detailed account of these three factors is described below in greater detail.

Table 3.14 Description and Strategies for Trustworthiness

	Credibility	**Transferability**	**Dependability**
Description	Level of confidence in the findings	Degree to which the findings apply in other contexts	Findings would be repeated if the study could be replicated
Strategy Used	Observing over an 18 week period Non-participant observation Collecting multiple sources of data Building the trust with participant Discussing the findings with the participant (member checking)	Selecting the research site and participants purposefully Providing detailed description of the context and data analysis	Providing detailed description of data collection process Using video to capture the conversation and activities in the classroom Inviting other researcher to examine the findings Portion of transcripts coded by another experienced researcher.

Credibility

For this particular study the length of engagement in the field and the recordings by the teacher of each teaching episode provided an element of prolonged engagement. The researcher sat in on 38 class sessions and recorded those sessions during the duration of the study. This prevented the researcher from being a “stranger in a strange land” (Lincoln & Guba, 1985, p.290). Each of the seven 200 minute segments were all nearly unbroken instruction over each 4-5 day period. This was possible because the teacher was willing to take recordings of the classroom when this researcher was not present. These recordings provided many opportunities to see if any distortions might have occurred because of the researcher being in the room during recordings. No major differences were detected by this researcher when viewing and transcribing videos other than in teacher-recorded video the camera never moved, causing some recordings to exclude the teacher from view. However, the teacher was always audible. On occasions when the researcher was present for recordings, the teacher would initiate chat with this researcher in the back of the room if students were working in small groups. This interaction happened a few times and suggested a level of trust between the researcher and teacher. Also, over thirty conversations were collected before or after lessons that helped to reveal the teacher's thinking over time. The teacher was very gracious with his time after class, which was usually a break time for him since his students were off to recess. Those conversations usually lasted from 3-7 minutes. In summary, the 38 plus in person visits, extensive video, and conversations provided persistent observation of the "scope" and "depth" (Lincoln & Guba, 1985) of the research.

All of the data had at least one other data source corresponding to it. Video and transcriptions, before and after lesson conversations, field notes, and interviews were data sources that overlapped for investigator triangulation. Member checking, which Lincoln and Guba (1985) describe as "…the most important technique for establishing credibility" (p. 316) was used during, after, and before lesson conversations to help this researcher better understand why or what the teacher did during whole-class dialogue. Many of the teacher quotes used in the results section came from question stems asked after a lesson that directly related to patterns of talk, critique and/or consensus-making. The results also benefited from the participant's review of an early write-up of the results section. These comments were also incorporated into the results presented in chapter four.

Transferability

Transferability is the ability of research results to transfer to situations with similar parameters. In this study the researcher provided "thick descriptions" (Creswell & Miller, 2000) of the rationale and background of the teacher selected for this study, data collection methods, and analysis methods. In particular, the teacher's use of the SWH approach or another approaches to ABI should be carefully noted in future research endeavors. Efforts should be make to insure that future researchers report the teacher's modified RTOP score and experience using ABI to help provide a sense of the teacher's overarching efforts in reform-based science instruction. If a teacher in a future study is not practicing the SWH approach a careful comparison should be made between the two practices to aid in interpreting and comparing setting and results.

Dependability

Dependability is an account of the ways in which the research is maintained as stable process overtime so it can be replicated. The classroom setting, the teacher’s credentials, location of cameras, conversations before and/or after the lesson, and interval of recordings did not vary during the length of the study to make the process seem or be unstable. Any changes in length of session, room configuration, placement of camera happened on rare occasions but were the exception and not the rule.

In a second effort to insure the dependability, about 10% of transcripts were scored by an experienced researcher who has analyzed classroom dialogue in past research projects. Conversations with this external reviewer showed that there was some confusion as to the way to interpret the difference between Talking with (TW) and Thinking through (TH) ideas with students. Descriptions in the coding category for TW and TH were reworked with the help of the external reviewer. The key distinction made during these conversations concerned the question of whose idea was driving the conversation. When it was students’ idea or ideas coming from students this was to be labeled as talking with (TW). When ideas that the students did not explicitly mention but were brought into the dialogue from teacher and discussed, those were thinking through (TH) episodes. This fine-tuning of category description allowed the external evaluator’s and researcher codes to be closer aligned. In the last round of external review of samples from each of the seven time segments, two of twenty-two (2/22) talking patterns were not in agreement and were discussed until there was mutual agreement.

Consensus codes were also checked. Early in the process, some differences were found in the overall coding. Descriptions for codes were revised to clarify and reduce coding inconsistencies. In a final external/researcher check of coding in 370 lines of transcript there were three instances where codes were not identified by both as a consensus event. Additionally there were three instances where both had coded a consensus event but assigned a different code. The external reviewer and researcher also decided that when consensus making was repeated back-to-back for the same idea that it was appropriate to code this as one instance. An example of this would be, "show of hands if you agree" or "let's go one by one and see if you agree or disagree with this idea, Kate? Bobbi? Jimmy? Ronnie?" In coding the latter example it was decided to represent this as one consensus event rather than four.

Lastly, an inquiry audit (Guba, 1981; Lincoln & Guba, 1985) was used to judge the processes used in this study (Anfara, Brown, & Mangione, 2002). This auditor reviewed the overall process, transcripts, methods, and results to attest that it is internally coherent from raw data, methods, results, and discussion. The auditor asked questions along the way and provided when appropriate, typed comments and recommendations to insure coherency.

Summary

This study attempts to understand whole-class dialogue patterns and consensus making episodes that occur and develop over time in a fifth-grade science classroom using argument-based inquiry. Qualitative methods were used to understand how patterns and episodes occur and develop overtime. Four sources of data used in this study were classroom video, semi-structured interviews, informal conversations before and after selected lessons, and researcher's field notes. Strategies such as purposeful selection of the teacher, long periods of observation, extensive video recording, checking of coding procedures by an experienced outsider, and member check all help to enhance the credibility, transferability, and dependability of the study.

CHAPTER FOUR

RESULTS

Introduction

The purpose of this study was to investigate the ways in which a teacher using science argumentation through the science writing heuristic (SWH) establishes and refines classroom dialogue over time. Two following specific research questions were addressed: (1) What were the initial whole-class dialogue patterns established by a fifth-grade science teacher who engaged in ABI? (2) How did the science teacher help to refine whole-class dialogue to support the consensus-making of ideas constructed over time?

Table 4.1 Matrix of Findings and Sources for Data Triangulation

Major findings	Source of Data			
	T	I	C	F
Question 1: What were the initial whole-class dialogue patterns established by a fifth-grade science teacher who engages in ABI?				
1st Finding: Teacher talked less as time went on while the overall total time of students in talk and activity increased as time went on.	x	x	x	
2nd Finding: In unit one the teacher spent about equal time in each of three talk patterns. In the second unit about half of all teacher talk was thinking through (TH) ideas with students while the other two patterns remain nearly equal.	x	x		
3rd Finding: In unit one, before and/or after episodes of student only (ST) talk the teacher was talking to (TT) students 75% of the time. In unit two when ST occurred, 75% of the time the teacher's actions before and/or after these episodes involved the teacher thinking through (TH) ideas with students.	x	x	x	x
Question 2: In what ways does the science teacher help to refine whole-class dialogue to support the agreeability of ideas constructed over time?				
1st Finding: More than 45% of all these instances of consensus-making by the teacher occurred in the first 6.5 hours of the 23.5 hours analyzed.	x	x	x	x
2nd Finding: Classroom engagement in critique by the end of the second unit was still under development. The teacher described critique as agreeing/disagreeing and telling why but does not use the word critique with students in any video analyzed in this study.	x	x	x	

Note: T = Transcript, I = Interview, C = After lesson conversation, F = Field note

First Research Question

The first research question for this study was: What were the initial whole-class dialogue patterns established by a fifth-grade science teacher who engaged in ABI? In order to answer this question, an in-depth analysis of whole-class dialogue patterns was conducted for the pre-unit, first unit, and second unit of instruction. Approximately two hundred minutes from each of the beginning, middle, and end of each unit as well as the pre-unit were analyzed. Three types of patterns of teacher talk were found to occur in this study; first, talking to (TT) students, second, talking with (TW) students, and finally thinking through (TH) ideas with students. The TT pattern was mostly a teacher monologue about some procedure, expectation, or summary of the events. The TW pattern occurred when the teacher was helping students to articulate their ideas so they could be expressed or explained to other students about a particular idea. Finally, the TH pattern involved the teacher helping students to explore and inspect other students' ideas, the teacher's ideas, and ideas of science.

Three findings emerged from this analysis. First, as both units progressed the teacher talked less as time went on and conversely student talk and activity increased as time went on. Second, in unit one the teacher was talking to (TT), talking with (TW), and thinking through (TH) students' ideas in approximately equal amounts. In the second unit about half of all teacher talk was TH ideas with students while TT and TW remained about equal. Third, in unit one when students talked (ST) without the teacher during whole-class conversation, 75% of the time the teacher's action before and/or after these episodes involved the teacher talking to (TT) students. In unit two, when ST occurred, 75% of the time the teacher's action before and/or after these episodes involved the teacher thinking through (TH) ideas with students. These findings provided opportunities to understand how characteristics of whole-class dialogue in one ABI classroom shifts and changes as the teacher's patterns of interaction change over time.

First Finding

First Finding: As both units progressed the teacher talked less as time went on while the overall total time of students in talk and activity increased as time went on.

As the videos were transcribed care was taken to insure that all the words spoken to the whole-class by the teacher were transcribed. The teacher's voice overall was easily distinguished in the room and almost always easy to hear on the audio track. Analysis of teacher's time actually talking and the number of words actually spoken by the teacher were counted. This offered two ways of seeing how talk progressed in the room over time (Finding two will discuss the type of talk in which the teacher engaged). Table 4.2 shows the number of words spoken by the teacher in each of the time segments.

Table 4.2 Words Spoken by the Teacher in Each Segment

Words spoken by the teacher				
Unit	Beginning	Middle	End	Total
Pre	-	6592	-	6592
First	10731	6297	5341	22369
Second	9430	5526	4708	19664

The pre-unit was a series of events where the class investigated a "blue tube" and made claims and tried to support it with evidence. The pre unit can be thought of as a mini unit with a beginning, middle, and end. In this way, the number of words spoken in this unit aligned most closely with the middle word count in each of the other two units.

Overall, the teacher averaged in all segments of talking to (TT) students about 154 words per minute. This was based on all times the teacher was the only person talking in the room across all segments of time. Table 4.3 shows a breakdown of how many minutes the teacher was just talking to (TT) students across all segments. This rate of talk was within what was considered a normal conversational pace of talking (Williams, 1998).

Table 4.3 Average Words per Minute During Talking to (TT) Episodes

Segment	Words spoken	Time in Minutes	Average words per minute
Pre Unit	3323	23.9	139
1st Beginning	2912	16.55	176
1st Middle	2140	13.1	163
1st End	2815	16.9	167
2nd Beginning	2014	12.85	157
2nd Middle	1439	11.05	130
2nd End	725	5.45	133
Total	15368	99.8	154 (average)

In other segments teacher talk also happened with and between student talk. As mentioned before, only teacher talk was fully transcribed. In segments where the teacher was talking with (TW) and thinking through (TH) ideas with students the total number of words spoken by the teacher was divided by the average rate the teacher talked (154 words per minute). This gave an approximation for the actual time the teacher spent talking vs. the actual time the students spent talking in TW and TH segments. Table 4.4 shows the actual times the teacher was talking to (TT) students and an approximate time the teacher talked during TW and TH conversations. Figure 4.1 shows a graphical representation of this same relationship. This representation provides a measure of time spent rather than words spoken of the ways in which teacher talk changed as time went on.

Table 4.4 Approximate Time in Minutes in Each Segment the Teacher was Talking in Class

Segment	Talking To (TT)	Talking With (TW)	Thinking Through (TH)	Total Time
Pre Unit	23.9	13.1	8.1	45.1
1st Beginning	16.6	36.2	14.5	67.3
1st Middle	13.1	6.5	19.1	38.7
1st End	16.9	1.9	14.6	33.3
2nd Beginning	12.9	10.8	37.3	61.0
2nd Middle	11.1	13.7	12.8	37.6
2nd End	5.5	5.1	20.8	31.3

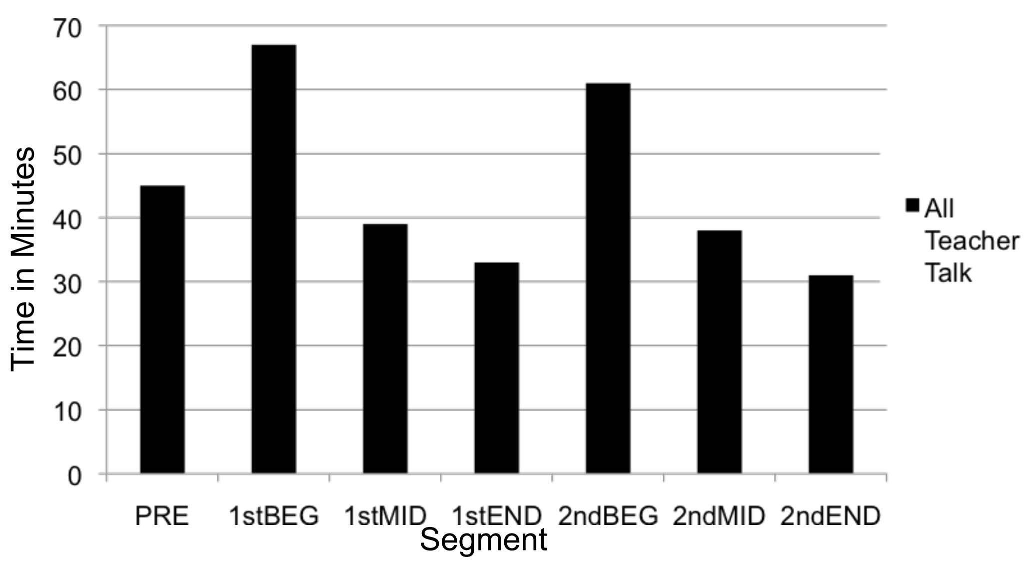

Figure 4.1. Approximate time in each segment teacher was talking in whole-class

In an interview with the teacher at the start of the school year, he described what he does at the beginning of the first unit by saying,

> First unit, it's a lot of involvement, work on my part, working with them. Stopping lessons, or you know, things that were going on in

> class. Talking about this was what happens, this was what I saw, what did you see. What worked well, what didn't work well? What did you see me do, and what were you doing? So it's a lot of just stopping what happened. Or just pointing out, this was what I saw what do you think about it. And me directing them. (August 25 Interview, Line 93).

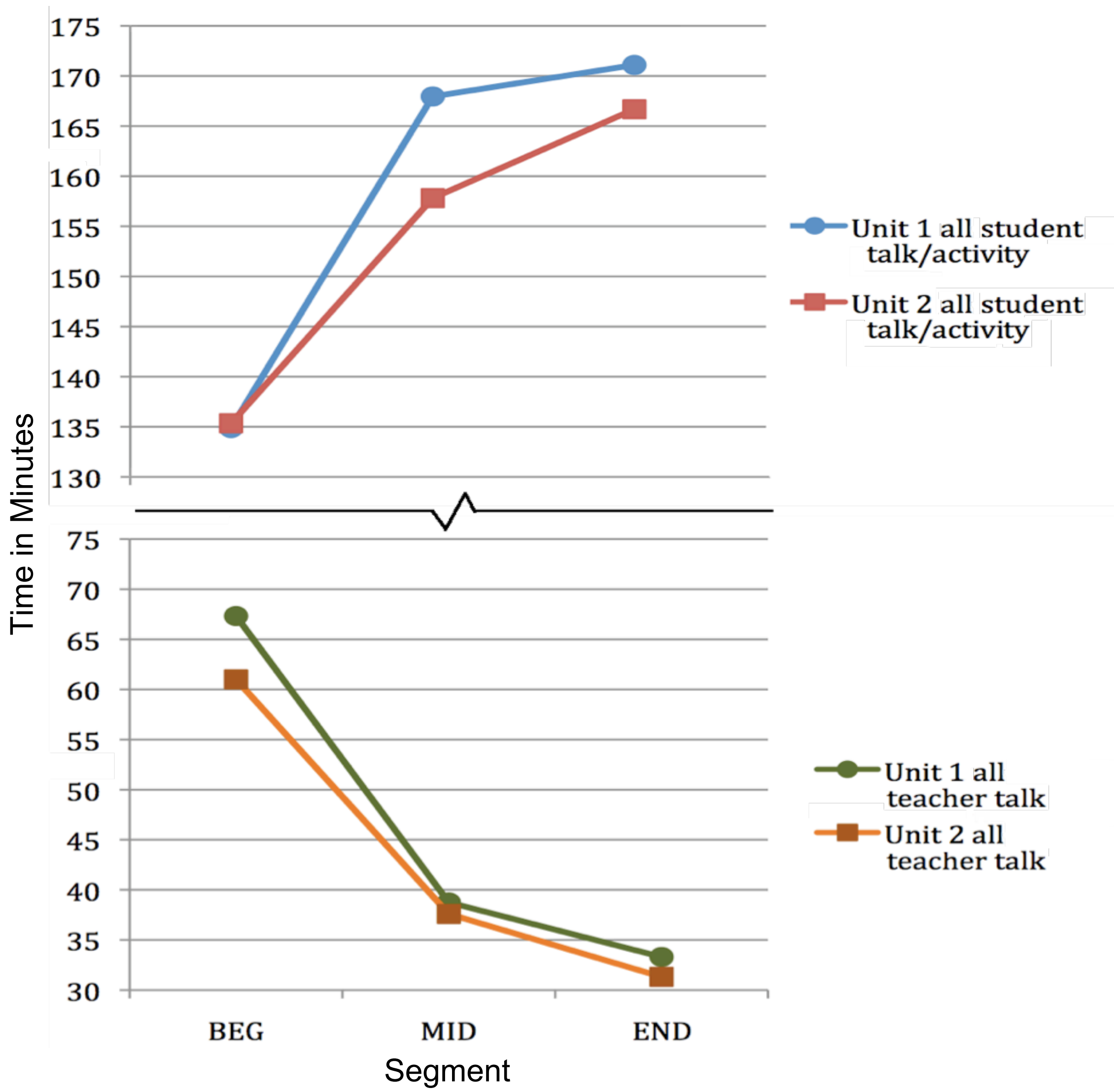

Figure 4.2 Approximate time in minutes in each segment of both unit of all types of whole-class teacher talk and all types of student talk and activity.

His description was consistent with the differences in teacher talk seen in Table 4.2 and Figure 4.1. In a later interview, after unit two started, he discussed student participation in whole-class conversation. His position was that having many students participate in whole-class conversation was great. However, some students were not much into whole-class talk, but contributed in other ways. He believes that student progress has to be measured on how they were progressing through all aspects of classroom interaction (November 30 Interview, Line 39). Additionally, he noted that a shift began to happen within a unit of instruction when he suggested that, "the shift too happens where they'll start calling on other people. From experience, they start doing more as they get into the unit because they're expecting that everybody's getting caught up in the main ideas" (November 30 Interview, Line 42-44). Figure 4.2 depicts how overall student talk and activity increased as each unit progressed. Conversely, the teacher in both units talked less (see Table 4.3) as the unit progressed. Finding two will address how the nature of teacher talks shifted as each unit progressed.

Second Finding

Second Finding: In the pre-unit the teacher was talking to (TT) students for about half of the time and thinking through (TH) ideas about twenty percent of the time. By the second unit the teacher was talking to (TT) students about twenty percent of the time and thinking through (TH) ideas with students more than fifty percent of the time.

Talking To (TT) Pattern

The teacher in the pre-unit spent about half of all his whole-class time talking to (TT) students. This type of talk was mostly monologues about some procedure, expectation, or summary of the events that happened or were expected to happen. Whatever the directed message, these were moments when the teacher was the only voice talking and the teacher created an expectation that students would stop what they were doing and listen. Table 4.5 was an excerpt from the longest TT episode. In this example, the teacher started off by purposefully stopping conversation and at the end encouraged them to resolve their word usage issue.

Table 4.5 Excerpt from the Longest Talking To (TT) Episode by the Teacher

Classroom transcript of teacher talking To (TT) students
Line 427 – 433 Start time 22:23 "OK I am going to stop you for a second. Alright, actually for more than a second. Twenty minutes have gone on and we're trying to figure out what possible is and what not possible is, Right? So we're really kind of negotiating. Every single science period we've negotiated whether it has been in a small group, large group, by yourself, with me. Right you have been negotiating all along. This is just a different form. It is not about a claim or evidence. It's about a word: Possible." Line 433- 521 (not included here) Lines 521-523 "I'll turn it back to you. Don't be afraid to look at me, but I'm not giv'n you the body language or response you're looking for. So, define possible or not possible. She is still waiting to write a definition on the board." End time 29:11

Note: [PreUnit Transcript: August 27, Lines 427 – 523]

All of the other TT episodes were shorter than this example provided in Table 4.5. Most of the episodes of TT were relatively short, with the frequency of TT episodes being much higher in the pre-unit and first unit. Additionally in terms of minutes, TT episodes were longer in the first unit than in the second unit. Figure 4.3 and Table 4.6 depict these frequencies and approximate length of each episode.

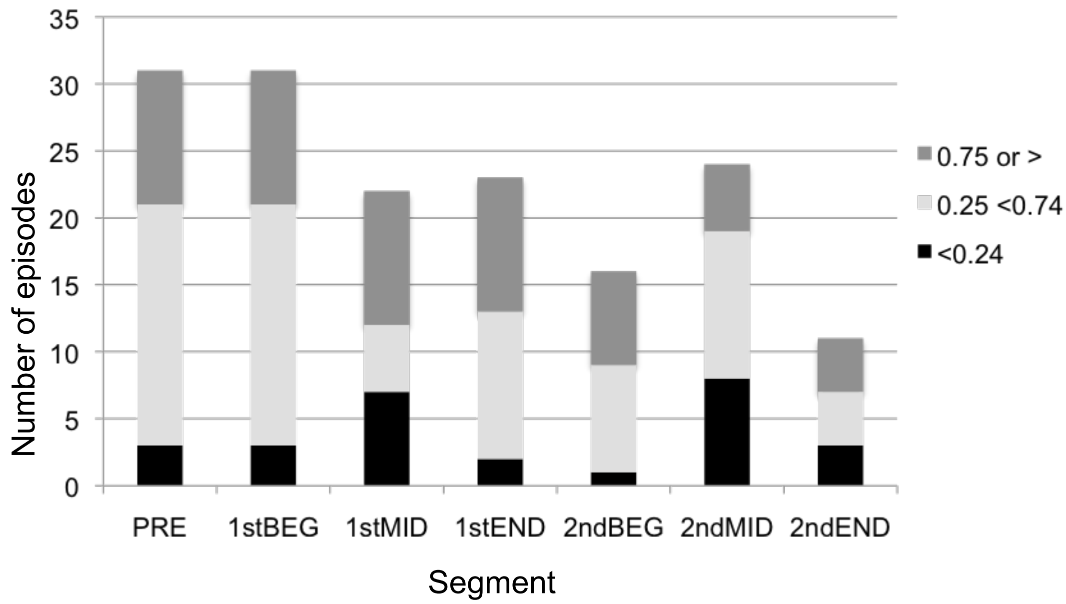

Figure 4.3 Frequency of talking to (TT) episodes by teacher. Less than 0.24, 0.25 – 0.74, and 0.75 or greater minutes per episode.

Table 4.6 Frequency of Talking To (TT) Episodes by Teacher.

	Number of Episodes			
Segment	<0.24 Minutes	0.25 <0.74 Minutes	0.75 or > Minutes	Total Episodes
Pre Unit	3	18	10	31
1st Beginning	3	18	10	31
1st Middle	7	5	10	22
1st End	2	11	10	23
2nd Beginning	1	8	7	16
2nd Middle	8	11	5	24
2nd End	3	4	4	11

There were only four instances in which the TT episodes lasted more than three minutes in the 23 hours of video analyzed. In the pre-unit there was a 6.5 minute episode (see excerpt in Table 4.5), 3.25 minute episode in the start of the 2nd unit, and one 3 and one 5 minute episode in the middle of the second unit. At the start of each of these longer episodes the teacher was clear that he was stopping classroom talk to talk to them. In total, for all the data used in this study there were 158 TT episodes, and 98 of those were less than 0.75 minutes. In the longer episodes there were more formal starts and stops to this type of talk in which students were asked to stop or listen. Smaller episodes were generally quick with a focus on in and out messages. Table 4.7 depicts examples of three smaller TT segments.

Table 4.7 Examples of Shorter Talking To (TT) Episode by the Teacher

Segment	Classroom Transcript
PreUnit	I am going to shift you a little bit. I want the front row. You're all facing the front [August 27 Video, Transcript, Line 378-379, Time 11:16 - 11:25]
1st Unit End	Alright going back to your brochure. You started to sketch out what you think you want the brochure to look like. I want you to look and see if you have some of those text features that help your audience or if you need to include some to help them. [October 27 Video Transcript, Line 4218 - 4220, Time 20:10 - 20:22]
2nd Unit Mid	While he is sketching his ideas, talk about what you heard him say. [December 14 Video Transcript, Line 2845, Time 12:23-12:26]

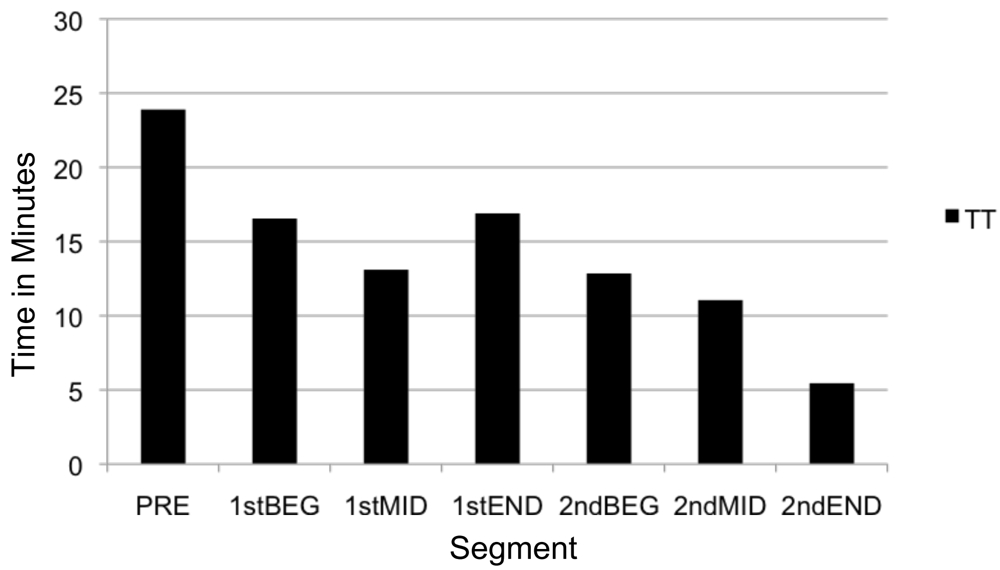

Figure 4.4 Total time teacher speaks during each talking to (TT) segment.

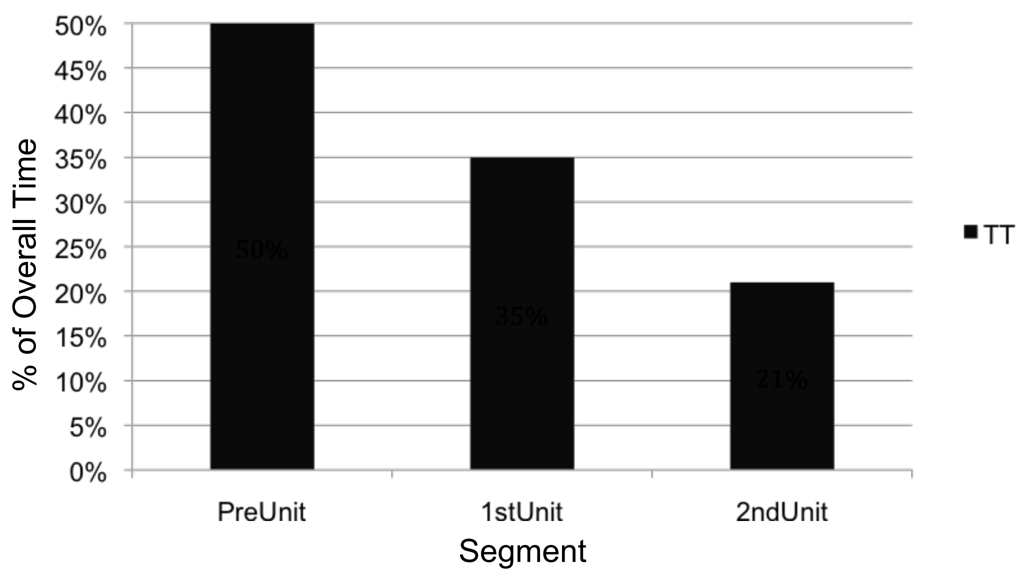

Figure 4.5 Percentage of overall time in each unit the teacher was talking to (TT) students versus all other types of teacher talk.

In summary, TT episodes decreased as time went on and overall less time was spent per TT episode as time went on. Figure 4.4 shows actual time in minutes spent by the teacher in TT episodes, and Figure 4.5 shows the percentage of overall time in each unit the teacher was TT students versus all other types of teacher talk.

Talking With (TW) Pattern

The teacher in the pre-unit and 1st unit spent an equal percent of time engaged in talking with (TW) episodes (see Figure 4.6). TW episodes were those moments in which the teacher was helping students to articulate their ideas so they could be expressed or explained to other students about a particular idea. This also helped the teacher to begin to understand the range of student thought and action. Table 4.8 was a transcript of a shorter TW episode at the beginning of the first unit. In this example students were working out the way in which to define something as living, and the teacher became more involved with conversation. This example was representative of a typical TW episode.

In these TW episodes, students talked the majority of the time. In an early interview with the teacher he talked about these types of whole-class episodes and explains:

> At the beginning of the year I'm asking, you know, why? How do you know? Just kind of an open vague question, letting them have the space to actually go the direction they want to.
> (August 25 Interview, Lines 68-69).

In the 2nd unit, less time was spent on TW students because a greater percentage of time was spent in the 2nd unit with students talking (ST) without the teacher. There was also more engagement in group work. Figure 4.7 shows the approximate total time the teacher speaks and students speak during each TW episode. Overall students talk about 62% of the time in TW episodes while the teacher talks only 38% of the time. Table 4.9 shows these percentages.

Table 4.8 Example Excerpt of a Talking With (TW) Episode with Teacher and Students

Person	Classroom Transcript
Teacher	So Amy, what do you think about that? Do living things? Are they made of cells?
NOTE	[silence for 12 seconds]
Amy	I have no idea.
Teacher	What? Eddie, do you want to help her out?
Eddie	Yeah. I think every living thing is made of cells. Just about everything is made of cells. There are different blood cells.
Teacher	So does it have some key [teacher sneezes] So, are we changing our definition of living then from where we started?
Barbra	A little bit, because if when we had added on to it.
Teacher	Added on to it?
Randy	We're backing it up.
Barbra	We're adding more information.
Teacher	So living things, not saying we all agree with this, but it was started as a starting point. A lot of people echoed it. That they, what was that again Kathy?
Kathy	It breathes or grows
Teacher	It breathes or it grows, and made of cells.

Note: [1st Unit, September 3, Transcript, Lines 1453 -1477]

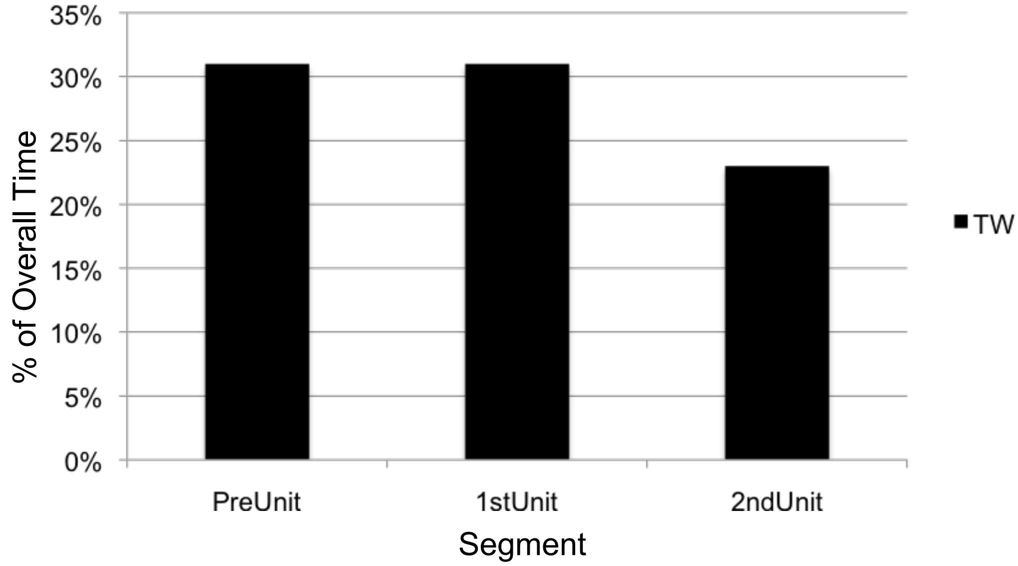

Figure 4.6 Percentage of overall time in each unit teacher was talking with (TW) students versus all other types of teacher talk.

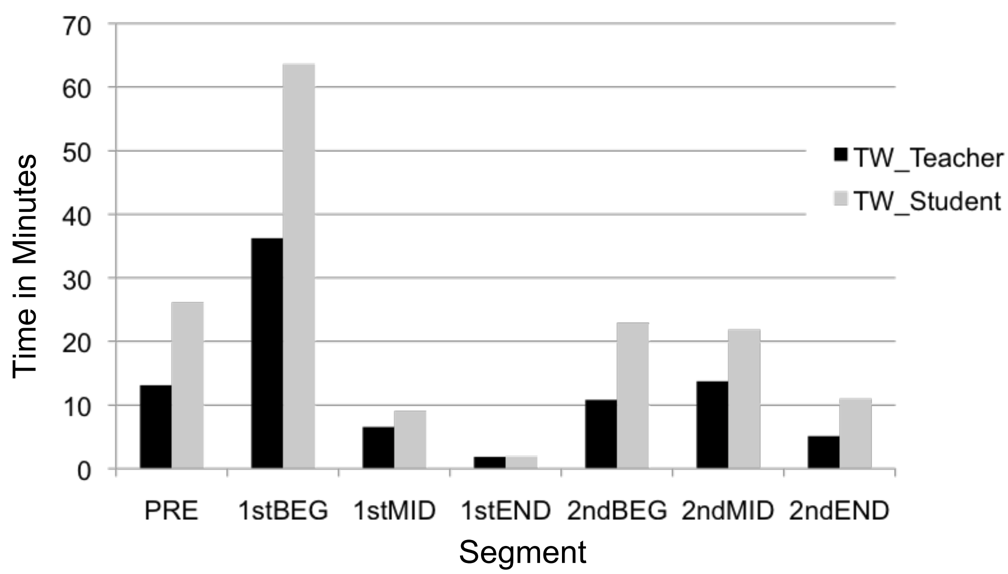

Figure 4.7 Approximate total time the teacher speaks and students speak during each talking with (TW) segment.

Table 4.9 Approximate Percent Time Teacher Spent Talking and Student Spent Talking in Talking With (TW) Episodes.

Segment	Teacher (TW)	Students (TW)
Pre Unit	33%	67%
1st Beginning	36%	64%
1st Middle	42%	58%
1st End	49%	51%
2nd Beginning	32%	68%
2nd Middle	39%	61%
2nd End	32%	68%
Average	38%	62%

Thinking Through (TH) Pattern

In terms of teacher talk, the greatest percentage shift happened in the amount of time the teacher spent thinking through (TH) ideas with students. TH episodes were those moments in which the teacher was helping guide discussion in which aired ideas were thought through, not only from the students' own ideas, but through further restatements of ideas, explorations and inspection of ideas, and moved toward more scientific ways of expressing thoughts. In the pre-unit only 19% of all the teacher's words spoken occurred in TH episodes. In the first unit this increased to 33% and in the second unit this increased to 56% of all the teacher's words spoken (see Figure 4.8). TH episodes were distinctly different than TW episodes in that the proportion of teacher talk to student talk was on average across all episodes equal (50/50). Figure 4.9 and Table 4.10 shows this relationship.

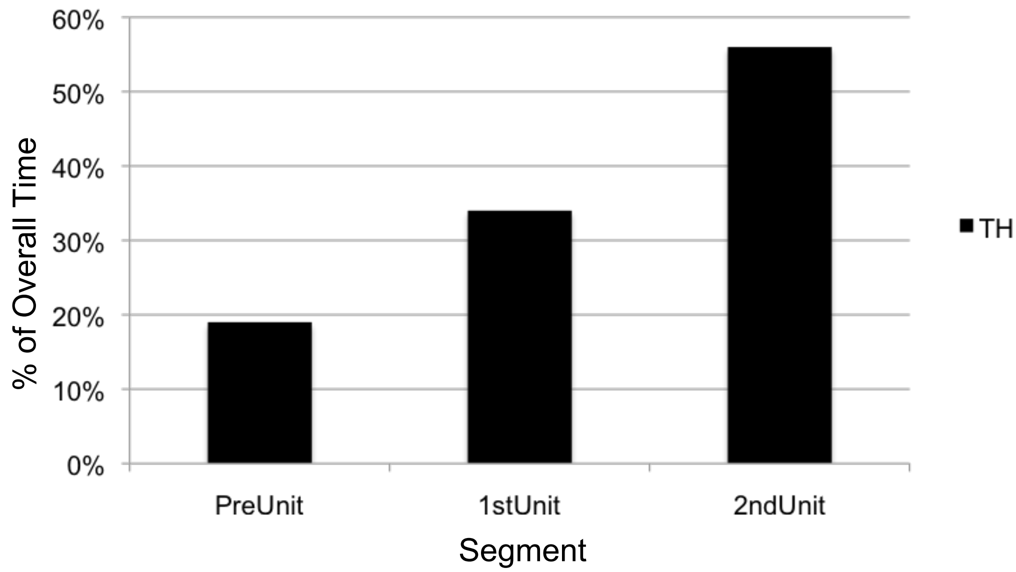

Figure 4.8 Percentage of overall time in each unit teacher was thinking through (TH) ideas with students versus all other types of teacher talk.

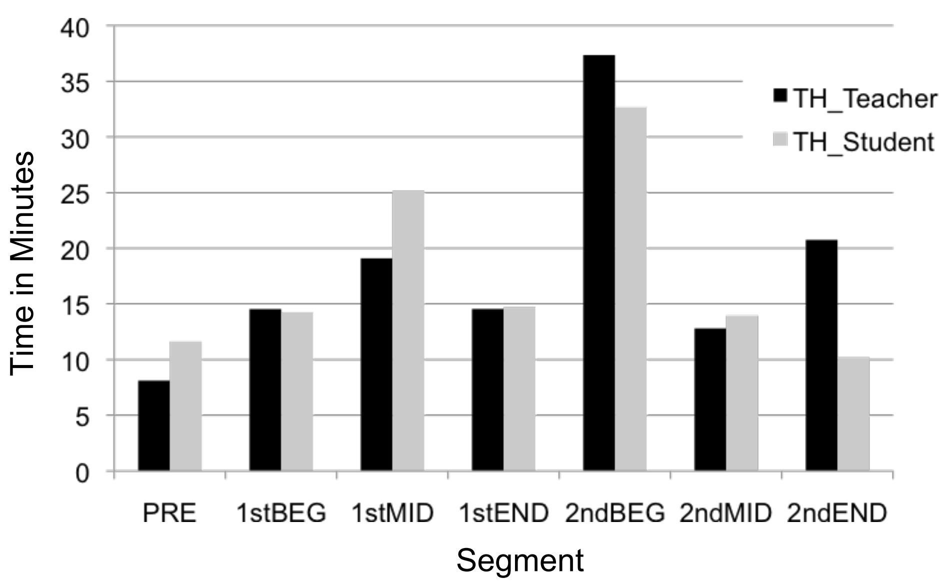

Figure 4.9. Approximate total time the teacher speaks and students speak during each thinking through (TH) segment.

Table 4.10 Approximate Percent Time Teacher Spent Talking and Student Spent Talking in Thinking Through (TH) Episodes.

Segment	Teacher (TW)	Students (TW)
Pre Unit	41%	59%
1st Beginning	50%	49%
1st Middle	43%	57%
1st End	50%	50%
2nd Beginning	53%	47%
2nd Middle	48%	52%
2nd End	67%	33%
Average	50%	50%

Table 4.11 was a transcript of a shorter TH episode at the beginning of the 2nd Unit (November 1). The teacher was helping the students to look at the ways in which they might be able to ask a more complex question as they began their unit of investigation.

The teacher in this example was very involved with insuring that the idea of better questioning was developed. The talk pattern helped ideas to develop with a back and forth volley with a clear purpose of trying to move student thinking about questioning. In an interview about two months before this transcript the teacher talked about how he planned to help students with formulating questions at the start of unit two. He stated:

> Getting into the second one [unit], we'll start looking at the level of questions. What happens if we pull out the Bloom's Taxonomy for example. We take one of these questions and move it through the different layers and levels, what's going to happen to the type of outcome or the answer. So, we take that one maybe okay worded question and move it all the way to you know, synthesis or evaluation. Then from that, then they start saying , 'Oh, these are the types of words I need to start using in my question'." (August 25 Interview, Lines 68-69).

Table 4.11 Example Excerpt of a Thinking Through (TH) Episode with Teacher and Students.

Person	Classroom Transcript
Teacher	Then what I am hearing multiple people say with the complex answer complex question there is multiple things I have to know to answer the question. Because there is a lot to it. Do you agree with that?
Many	Yeah
Teacher	OK. so which one of these should be simple which ones of these would be more complex.
Many	[students chatter about idea]
Teacher	OK somebody suggested, Randy said, this one is simple. because it gives a simple response. Do you agree with that?
Many	Yeah
Teacher	Any others we would use there?
Many	Yes
Teacher	Do you agree that, that one is more complex?
Many	Yeah
Teacher	So you're saying this one is more complex. This is a similar type question. What about those two?
Eddie:	[talks quietly to teacher who is next to him]
Teacher	Tell them.
Eddie	Hum.
Teacher	Tell them
Eddie	How a food chain works can be considered simple or complex question.
Teacher	So what he's saying, you can look at those two in different ways. So you can say it is simple depending on how you look at it. or you can say its complex depending how you look at it. Can you look at that one simply? is that a simple question?
Many	no, yeah, yes
Teacher	It would be really hard to look at it as a simple answer. Wouldn't it. I think it would.

Note: [2nd Unit September 3, Transcript, Lines 184-201]]

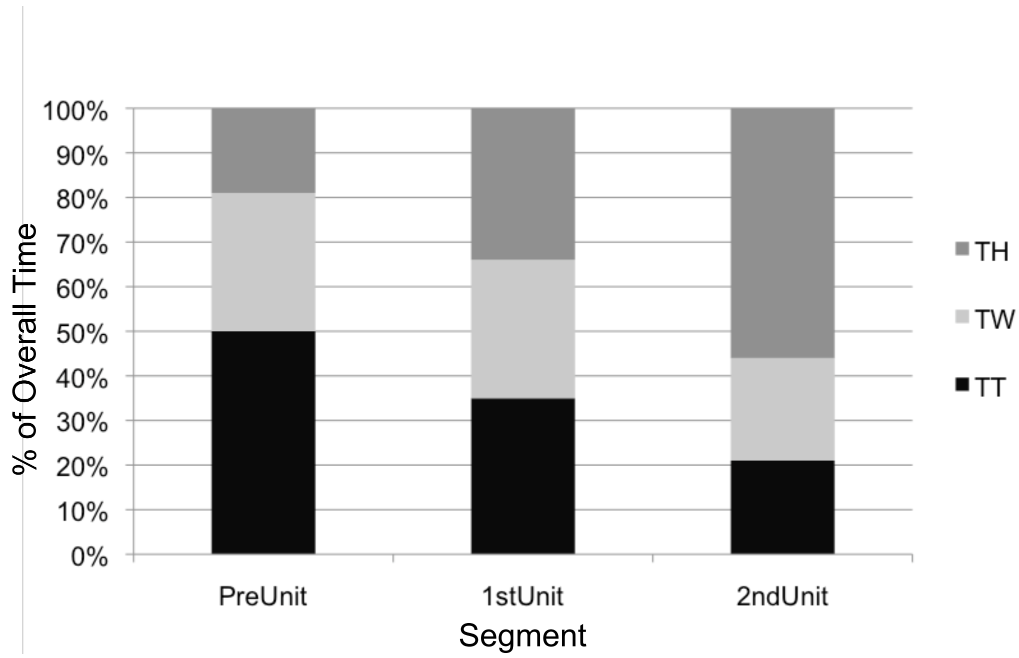

Figure 4.10 Percentage of time in each unit teacher was talking to (TT), talking with (TW) and thinking through (TH) with students.

As time went by, TT episodes were overshadowed by the teacher TH ideas with students (see Figure 4.10). Teacher talk, no matter the form, represented only a relatively small percentage of all whole class talking activity in the science class. During the first 200 minutes of both unit one and unit two the teacher talked only about one third of all those minutes. The rest of the time students were engaged in whole class talk, group work, or individual tasks. In both units, during the last 200 minutes the teacher talked only for about 16% of those 200 minutes (see Figure 4.11).

The talk patterns differed at the end of unit one vs. unit two. Students at the end of the first unit spent no time in student only whole-class talk, 63 minutes working in small groups, and 92 minutes working individually on their final unit projects in which they made a hand written brochure to later share with 4th graders. Half the time spent talking by the teacher (17 of 33 minutes) at the end of unit one was TT directing students on how to make an effective brochure. At the end of the second unit, the students spent 45 minutes talking as a whole-class without the teacher, about 94 minutes working in small groups, and about 7 minutes working individually. Most of the time spent talking by the teacher (21 of 31 minutes) at the end of unit two was spent in TH assisting students on how to refine their final claims and evidence for the unit.

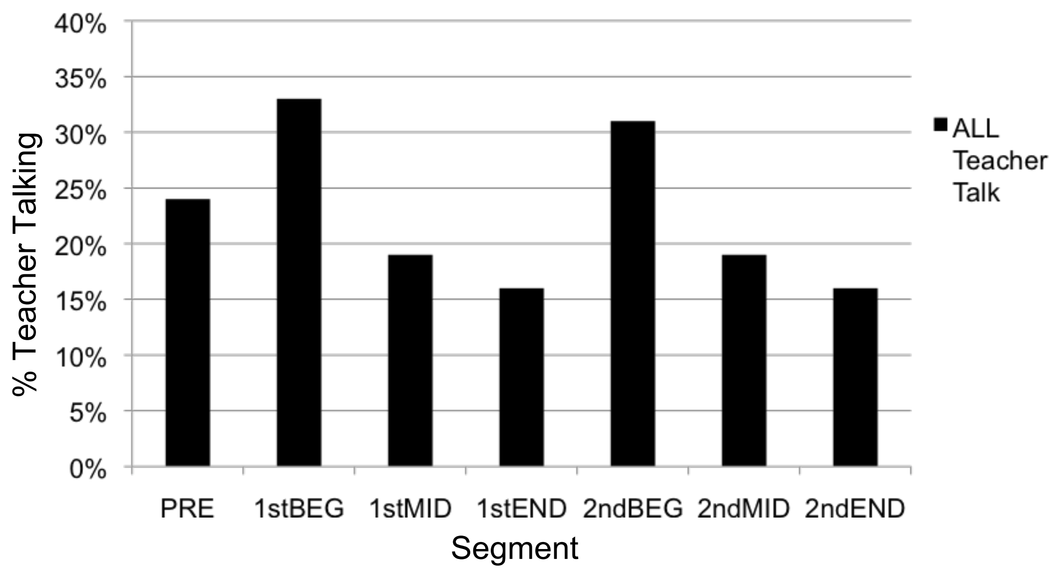

Figure 4.11 Percent of time teacher talked to whole-class during each 200 minute segment.

Third Finding

Third Finding: In unit one when the students talked (ST) without the teacher during whole-class conversation, 75% of the time the teacher's action before and/or after these episodes involved the teacher talking to (TT) students. In unit two, when ST occurred, 75% of the time the teacher's action before and/or after these episodes involved the teacher thinking through (TH) ideas with students.

Instances of student only talk (ST) were moments when students had multiple turns of talk without the teacher taking a turn in a whole-class setting. These episodes were at least 12-15 seconds each, and none, across all segments, lasted more then 7:45

minutes. Table 4.12 shows the time spent in student only talk, the number of ST only episodes, and the average length of time for each episode in each segment. Obviously, every ST episode had some event that came before or after it. In total, there were 111 episodes of ST talk across all segments. These were all public episodes in which ideas were publicly shared for all in the class to hear. 103/111 episodes had either a teacher talking to (TT), teacher talking with (TW), or teacher and students thinking through (TH) episode before and/or after the event. The eight other episodes, not included for this analysis had either group work (GW), individual work (IV), or were at the start or end of lesson.

Table 4.12 Total Time, Number of Episodes, and Average Time in Each Segment Students were Engaged in Student Only Talk (ST)

Segment	Total Time in Minutes of only Student Talk (ST)	Number of Episodes of ST	Overall Average Time in Minutes of ST
Pre Unit	40:48	17	2:24
1st Beginning	25:30	20	1:18
1st Middle	35:48	26	1:24
1st End	0:00	0	0:00
2nd Beginning	22:00	11	2:00
2nd Middle	19:00	17	1:07
2nd End	45:00	26	1:45

Overall, the type of talk that happened before or after ST episodes progressively shifted as each unit progressed. The pre-unit had the most student only talk (40:48 minutes) of any other segment except the end of the 2nd unit (45:00 minutes). In the pre-unit 59% of all ST episodes were more than two minutes in length (see Figure 4.12).

Additionally the pre-unit ST episodes averaged 2:24 minutes each. No other segment average was this long (see Table 4.12). However, the actions that happened before and after these episodes of ST talk in the pre-unit as compared to the end of the 2nd unit were quite different.

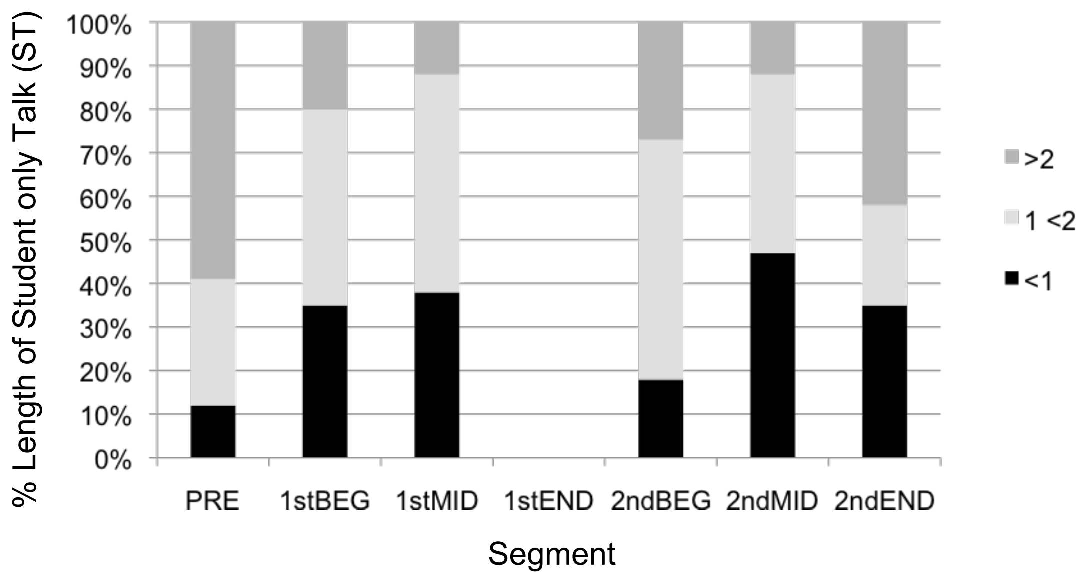

Figure 4.12 Percent of time in minutes students spent talking for each time range of ST episodes.

The amount of time granted for student only talk in the pre-unit represented a lot of space for whole-class student only talk considering it was early in the school year. During an interview the teacher talked about this space being given for students early in the school year and stated:

> I think the biggest thing at the beginning of the year was just the discussion. Getting the language out so they can start hearing each other. So voicing opinions. The two pieces are voicing an idea, but also listening. (August 25 Interview, Lines 26)

The teacher wanted the students to get accustomed to talking in class and listening to each other's ideas. The teacher in the pre-unit, during the 24 minutes worth of talking to (TT) episodes, mentioned on nine occasions that they needed to work on listening to their classmates ideas. Other TT episodes included procedural issues and directing and encouraging talk. In contrast, at the end of the 2nd unit, there was not one occasion where students were asked or reminded to listen to each other. Of the 5.75 minutes of TT at the end of the 2nd unit, most of the time was spent on giving guidance related to discussing power notes, key word outline, concepts maps, venn diagrams, and preparing for a think-pair-share.

Student only talk (ST) in the pre-unit was not always smooth or free flowing as in later segments. There tended to be more gaps with little or no talking. Table 4.13 was an example of pre-unit segment where the teacher was talking to (TT), then student only talk (ST) occurs followed by more talking to (TT) by the teacher. This transcript was a TT/ST/TT pattern and was found in 44% of all the pre-unit segments of ST. Additionally 31% of other ST segments in the pre-unit included before or after it a TT segment. In sum total 75% of all ST episodes in the pre-unit were accompanied, either before or after, by at least one TT episode by the teacher. As mentioned earlier, TT episodes typically give direction and guidance on which way to do something. These were not segments that helped to draw out students' ideas or develop student understanding as in TW or TH episodes. In the 1st unit, only 13% of the ST sessions followed a TT/ST/TT pattern. In the 2nd unit only 5% followed the TT/ST/TT pattern and additionally 20% of other ST segments in the 2nd unit included a TT segment before or after. In sum total 25% of all ST episodes in the 2nd unit was accompanied, either before or after, by at least one TT episode by the teacher. This relationship represents a nearly symmetrical shift in the pattern of whole-class talk from the pre-unit to the 2nd unit of instruction (see Figure 4.13).

Table 4.13 Transcript of a TT/ST/TT Pattern in the Pre-Unit.

Time	Person	Transcript	Type of Talk
0:53 - 1:00	Teacher	I think we are talking about two and five. Right? Are they the same or different. That is the question for you. you have to decide. I am not going to do that for you.	TT
1:01 - 1:10	Grant	One has a lot more strings than the other one. The idea is the same.	ST
1:11 - 1:20	Eric	When they explained, they explained it different ways. If you look at it, it would look similar. I'd say they probably are.	ST
1:20 - 1:39	--	[Students are not talking]	ST
1:40 - 1:49	Teacher	It's your guys' decision not mine. Are they the same or different? You need to talk together. I am out of your conversation.	TT

Note: [Pre Unit, August 26 Video, Transcript, Lines 145 – 156, Time 0:53 - 1:49]

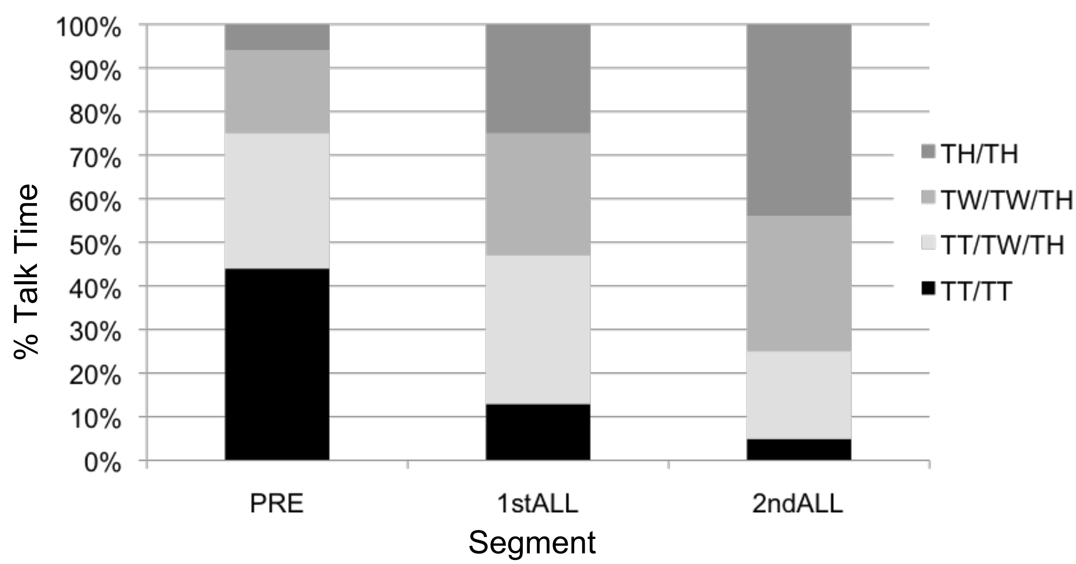

Figure 4.13 Percentage of type of whole-class dialogue in each unit before or after episodes of student only talk (ST).

As mentioned earlier in the second finding for this research question, in TW episodes the teacher talked, on average, about 38% of the time and students talked about 62% of the time (see Table 4.9). TW episodes were those moments in which the teacher was helping students to articulate their ideas so they could be expressed or explained to other students. The teacher took up ideas, observations, and evaluations the students introduced to encourage a range of student thought and action. Table 4.8 is an example excerpt of a 1st unit TW episode after a ST episode. In this example the teacher was helping students to hear what their classmates thought about the notions of living things being made of cells. This was a typical TW episode of the teacher drawing out student ideas. Over all segments of time, ST episodes were paired before and/or after with TW episodes 44% of the time in the pre unit, 49% in the 1st unit, and 42% in the second unit with an overall average of 45%. This was a consistently paired component with ST across all seven time segments.

The occurrence of thinking through (TH) episodes before or after ST episodes shifted from the pre-unit to the second unit. Figure 4.14 shows the occurrences of all variations in whole-class talk before and after episodes of ST. The pre-unit had 16 episodes of ST only talk (1/3 smaller of a unit than 1st or 2nd unit), 1st unit had 47 episodes, and 2nd unit had 48 episodes. However, 75% of all ST episodes in the second unit were accompanied by a TH episode. In contrast, 75% of all ST episodes in the pre-unit were accompanied by TT episodes.   In the 1st unit about half of all ST episodes were accompanied before and/or after by a TH episode (see Table 4.14 or Figure 4.13). TH episodes that come before and/or after ST episodes were usually part of a larger dialogue. There was a lot of back and forth by students/students and teacher and student. Table 4.15 was an example of a segment at the start of the 2nd unit where the class was TH ideas and then ST occurs then followed by TH.   This transcript represents a TH/ST/TH pattern. The teacher knowingly fostered this type of activity. This type of interaction was discussed with the teacher about two weeks later during a conversation noted in the field notes.

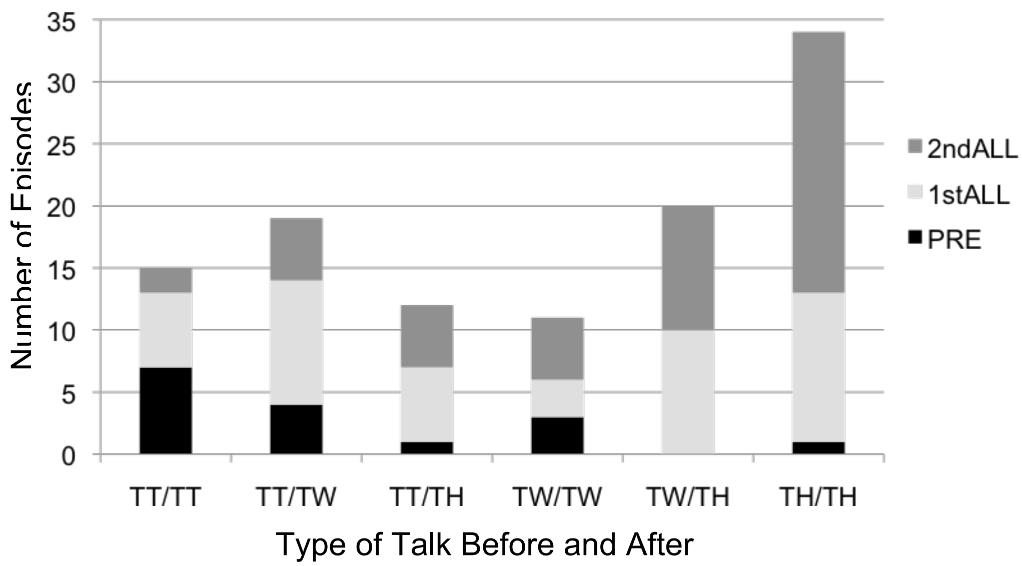

Figure 4.14 Types of Whole-class dialogue in each unit before or after episodes of student only (ST) Talk.

Table 4.14 Percentage of Type of Whole-class Dialogue in Each Unit Before or After Episodes of Student Only Talk (ST).

Type of Talk	Pre Unit	1st Unit	2nd Unit
TT/TT	44%	13%	5%
TT/TW or TH	31%	34%	20%
TW/TW or TH	19%	28%	31%
TH/TH	6%	25%	44%

Table 4.15 Transcript of a TH/ST/TH Pattern in the 2nd Unit

Time	Person	Transcript	Type of Talk
7:32	Teacher	ice cream cone goes in, what comes out?	TH
	Students	[chatter not transcribed] waste, excrement waste	TH
	Teacher	Waste comes out. What kind of waste are we talking about? What is waste?	TH
	Students	poop or pee, urine	TH
	Teacher	So waste comes out poop or pee. Does it look like an ice-cream cone?	TH
	Students	no. nooooo liquid or solid. looks like jello	TH
	Teacher	Ice cream cone kind of looks like the liquid part that's just frozen. and then there's the solid part that is just the cone.	TH
	Randy	no you chew it	TH
	Teacher	So then the ground up ice cream cone comes out. Then there's melted ice cream that comes out of you?	TH
8:22	Eric	Your body is taking out the things it needs	ST
	Barb	you have to chew it, stomach acids break down food	ST
	Students	[other student chatter and talk not transcribed]	ST
	Randy	you body empties the bad stuff and keeps the nutrients	ST
	Students	lots of chatter [not transcribed]	ST
	NOTE	[teacher is listening to class with hands folded.]	
9:22	Teacher	OK. but our question was, how does your body get the nutrients from the food you eat? right. that is where we are starting from. You seem to have a pretty good understanding of what it looks like. are you pretty confident with that?	TH
	Many	[yeah]	TH
	Teacher	Does it kind of match our dude hanging up on the shelf?	TH
	Students	kind of, little more graphic exact [other chatter]	TH
	Teacher	A little more scientific?	TH
	Students	A little more 3D, it only has one eye.	TH
	Dan	Face has one side.	
	Teacher	Sure Dan. when we are talking about how food is broken into nutrients, we are really trying to figure out what part of the body was what to food. alright.	TH
	Many	Yeah. Yes.	TH
	Teacher	So once your food goes past this point, do we really don't know what happens?	TH
10:11	Many	No, Not really, No.	TH

[2nd Unit, November 10 Video, Transcript, Lines 778 - 809, Time 7:32 - 10:11]

> The teacher struggles with the problems of when to interact, how much support to give, and if the time was well spent. The teacher also notes that they seem to have all the pieces but don't have the skills to put it all together. The teacher realizes this takes time and wonders how he should best help students assemble those parts. (November 29 Field Notes)

In this way, the teacher recognized the need to TH ideas with students. Figure 14.15 graphically represents this transition in progress. In the beginning of the 1st Unit there were many more episodes of TT and TW. TT was 100% teacher talking and TW was the teacher talking about 62% of the time (explained in Table 4.9, p. 86). In the start of the 2nd unit, although less episodes overall, there was a notable shift to more TH talk and less TT. Finally at the end of 2nd unit there were many episodes of TH and ST relative to TT and TW episodes. The end of the 1st unit was not used in this graphical comparison for Figure 4.15 because there were no episodes of ST because students spent 92 minutes in that segment individually preparing their end of the unit project. This was the most private time allocated to students in any segment of this study. However, there were still 23 episodes of TT, 3 episodes of TW, and 7 episodes of TH in that end of the 1st unit segment.

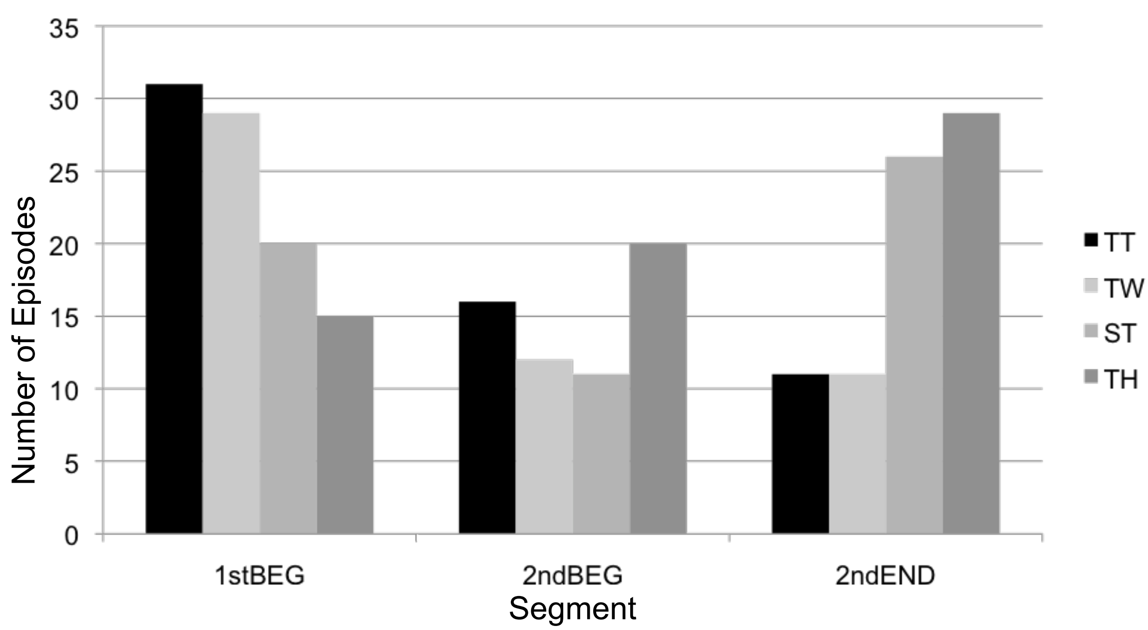

Figure 4.15 Number of Episodes in each segment of teacher only talk (TT), talking with (TW), student only talk (ST), and thinking through talk (TH).

In the first TH episodes at the end of 1st unit (1st Unit, October 25 Video, Transcript, Lines 3478 - 3780, Time 22:40 - 40:40) the class was thinking through (TH) the ways in which their ideas changed since the start of the unit. This episode lasted 18 minutes and was the longest TH episode in any segment. It was a dialogue about their initial questions from the unit and the ways in which their ideas have changed. After that dialogue ended they worked on their brochure project that served as their unit assessment. The six other TH episodes at the end of the unit were about thinking through the ways in which students might present information in their brochure to their 4th grade audience. TT episodes in this segment tended to be less than 30 seconds each and involved giving direction/guidance to students as they assembled their brochure. In contrast, the end of the 2nd unit had only about 7 minutes of Individual work. Students' work at the end of the 2nd unit focused on more public work in groups preparing, presenting, and negotiating their revised claims and evidence that fostered many opportunities for ST, TW, and TH episodes.

At end of the 1st unit their individual constructed representation of their understanding was the chosen activity. In the case of the second unit, the public work of preparing, presenting, negotiating, and revising claims and evidence fostered many more opportunities for dialogic interactions.

Second Research Question

The second research question for this study was: How does the science teacher help to refine whole-class dialogue to support the consensus-making of ideas constructed over time? In order to answer this question, an in-depth analysis of whole-class talk that included the teacher was coded for moments when the teacher was fostering and/or reinforcing ideas for the class as a whole to reach consensus.

Consensus-making by the teacher primarily occurred when the teacher asked students to say yes/no or agree/disagree to some idea. The teacher also recognized when students reached consensus, or reminded the students to reach consensus on a particular idea. Seven types of consensus-making were identified from this study as follows:

ccs Teacher asked class consensus of student idea
(e.g. "how many say" "show of hands" , "yes/no" type question

sad Teacher recognition of student agreeing/disagreeing
(e.g. "x agreed so", "I heard", "you all agree", "I am hearing")

sai Teacher called on a student to hear agreeability of idea
(e.g. "x do you agree?", "what do you think")

tra Teacher reminded students of their past consensus
(e.g. "we said", 'you all said")

sju Teacher asked a student justification for agreement
(e.g. "why do you agree", "why did", because?")

rsa Teacher reminded students class needs to reach consensus or agreement
(e.g. "talk to them")

tad Teacher agreed or disagreed with student idea

Two findings emerged from this analysis. First, consensus-making instances fostered by the teacher occurred frequently in the pre-unit and beginning of the 1st unit. More than 45% of all these instances occurred in the first 6.5 hours of the 23.5 hours analyzed. The decrease in frequency, in part, can be attributed to student involvement in whole-class dialogue and their expressions of their own agreeability without the teacher first asking for it. Second, classroom engagement in critique by the end of the second unit was still under development. The teacher described critique as agreeing/disagreeing and telling why but does not use the word critique with students in any video analyzed in this study. These findings provided opportunities to understand how agreeability within whole-class dialogue in one ABI classroom shifts and changes as the teacher's and students patterns of interaction change over time.

First Finding

First Finding: Reinforcing consensus-making instances fostered by the teacher occurred frequently in the pre-unit and beginning of the 1st unit. More than 45% of all these instances occurred in the first 6.5 hours of the 23.5 hours analyzed. The decrease in frequency, in part, can be attributed to student involvement in whole-class dialogue and their expressions of their own agreeability without the teacher first asking for it.

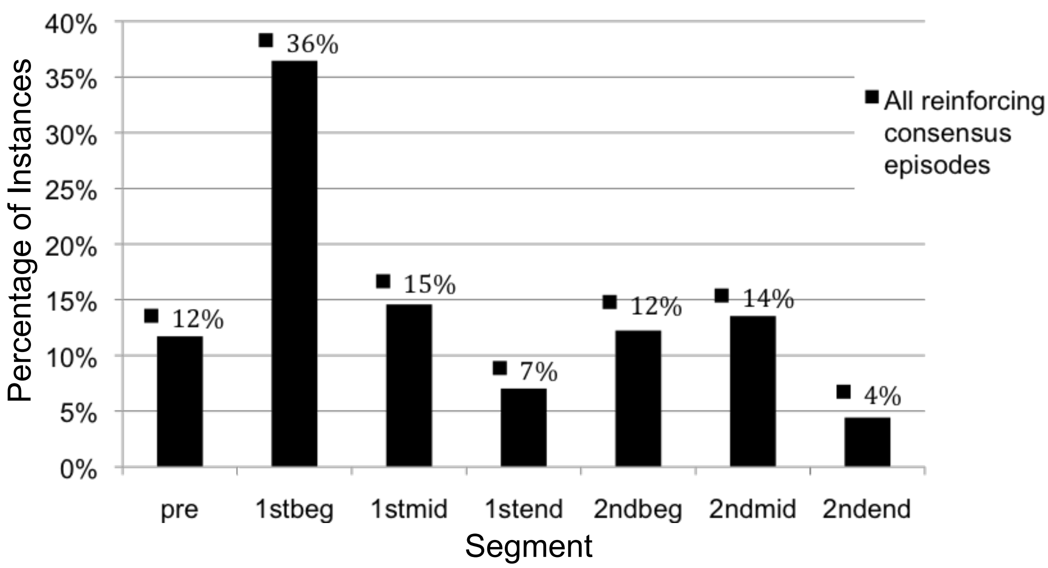

Figure 4.16 Percentage of all consensus instances per segment.

Reinforcing consensus-making instances fostered by the teacher were most frequent in the beginning of the first unit and accounted for 36% of all instances across time. Between 12-15% of all other codes happened in the pre-unit, middle of the 1st and 2nd unit (see Figure 4.16). The end of both units had the fewest codes but these segments also had the least amount of teacher talk and the most time with student talk, individual work, and group work that did not include the teacher. In part, as time when on, teacher initiated consensus-making decreased as students began to take on the task of asking each other for consensus and as students became more involved in expressing their own individual agreeability over time without the teacher asking for it.

In the beginning of the first unit the teacher interacted frequently with students. He saw his work as involved in the beginning of first unit. He stopped the lesson more often to talk about what he and they saw as working or not. He also directed them in the direction he thought they should go. In an interview near the start of the year he described his involvement in the classroom.

> First unit, it's a lot of involvement, work on my part, working with them. Stopping lessons, or you know, things that are going on in class. Talking about this is what happens, this is what I saw, what did you see. What worked well, what didn't work well, what did you see me do, and what were you doing? So it's a lot of just stopping what happened. Or just pointing out, this is what I saw what do you think about it? And me directing them of, you know I think it's time for negotiation lets go towards that.
> (August 25 Interview, Lines 93-95)

In the middle of the 1st unit students were trying to decide whether to use the term nutrients or food in describing the needs of a deer. In a talking with (TW) episode, conversation began to go in many directions and the teacher stopped the episode and talked to (TT) them about their conversation (see Table 4.16). In this almost one minute episode, he talked with them about what was not working with their talk and that having a conversation is not about "shouting different things at the same time". After this episode, students' talk (ST) with each other lasted for about a minute.

Table 4.16 Transcript of a TT Episode in the Middle of the 1st Unit

Line	Person	Transcript
2599	Teacher	STOP. When we're sharing ideas I'm OK with not raising hands, however if we're all shouting different things at the same time do we get anywhere.
2600	Students	[chatter food nutrients]
2601	Teacher	STOP, Deb. Stop means stop talking. He says nutrients because nutrients come from food and some of you are just yelling food back at him. Is that getting us anywhere?
2602	Students	[no]
2603	Teacher	Third time. manage yourselves and have a conversation together Thomas say your point.

Note: [1st Unit, September 22 Video, Transcript, Lines 2599 - 2603, Time 24:08 – 25:02]

Table 4.17 Transcript of a ST Episode in the Middle of the 1st Unit

Line	Person	Transcript
2608	Thomas	Well the nutrients are in the food yes, and so it could be food. but is not always necessarily that it has to be food. There are different types of foods that might not be good for you. But it's food. But it won't need all kinds of food. It just needs the nutrients.
	Students	[others start to talk. Deb's voice prevails]
	Deb	Well, but yeah like I agree with Thomas because, I agree with Thomas because if it's kind-of like a dog with chocolate. If a dog has chocolate it will die or something like that or get really sick. Then if maybe a deer finds something to feed on like people food on the road and eats it, it might die or get really sick like a dog eating chocolate. [Deb mumbles something else as others try to talk]
	Students	[several students talk over each other]
	Randy	Yeah, I think it should be nutrients

Note: [1st Unit, September 22 Video, Transcript, Lines 2608, Time 25:12 – 26:27

Thomas and Deb primarily talked then others talked over each other or did not really talk beyond their table area (see Table 4.17). Deb mentioned she agreed with Thomas. The students were still not making progress in deciding to say a need of a deer was food or nutrients. The teacher stepped in and had a thinking through (TH) episode with the students. After about one minute along with three consensus-making moments they all agreed to use the word food instead of nutrients (see Table 4.18).

Table 4.18 Transcript of a TH Episode in 1st Unit where Consensus-making Instances Occurred

Line	Person	Transcript	Consensus Code
2624	Teacher	So what's a word as a class we can move forward on.	
2625	Teacher	**Thomas is shaking his head. He's not OK with that.**	sad
2626	Teacher	[many start to talk - Barb's voice prevails]	
2627	Barb	Nutrients is good but...we need to know	
2628	Barb	a little more about nutrients.	
2629	Students	[short chatter]	
2630	Teacher	**How many of you know a** lot about nutrients.	ccs
2631	Students	[two hands go half-way up]	
2632	Teacher	**How many of you know more about** the word food?	ccs
2633	Students	[most all hands go up]	
2634	Teacher	So if put food down will we know what that means for a deer? when we say food Thomas are we talking about cheese burgers?	
2635	Students	[Thomas shakes head - other giggle]	
2636	Teacher	So when we say food for a deer what kind of food are we giving the deer?	
2637	Students	[grass] [clover] [apples]	
2638	Teacher	grass, clover, apples, different kinds of plants	
2639	Students	[vegetables] [other mumbles]	
2640	Teacher	**so class can we move on** food and just say food?	ccs
2641	Students	[most say yes]	

Note: [1st Unit, September 22 Video, Transcript, Lines 2624 - 2641, Time 27:32 - 28:40]

The teacher was interviewed after that lesson and was asked how whole-class dialogue was progressing at that time. He said:

> A lot of it's just, I don't know how to describe it. It's like a tug-of-war. We're shifting our position based on our experience and interaction together. At the beginning of the year, the first week, it was really messy. We're to the point where it's still messy but it's not shifted so much towards all of those random conversation. Another thing in this class at the beginning, they were just staring at each other. So we shifted from sitting and staring to all kinds of conversation, but now we have to shift that to, what is respectful listening and speaking so we can move with a purpose rather than just mindless chatter. Just an observation I had, we're now on the shift of controlling conversation toward purpose.
> (September 22 Interview, Line 11-13).

A week later in an after lesson conversation the teacher also noted that some students were explaining why they disagreed and he saw this as a maturing of language in the classroom. He says, "A couple of the boys are starting to say 'I don't agree with how you have it phrased, can you say this' And that's what will happen as we start maturing with our language" (September 29 Interview , Line 12).

The teacher was also asked about his past practice and what he might have struggled with several years ago. He said, "I probably would have been leading the discussion." In a follow-up question he was asked if he leads discussion now. He stated, "Part of it is chiming in and redirecting them. It's more of a redirection, change of direction, than 'this is what we're doing', 'this is where we're going'. As they continued in the middle of the first unit he saw a change in their conversation. "Now they're also starting to do something with their own conversation, calling each other out. But that's also because we've been practicing and getting more people involved" (November 16, Interview, Line 9, 13, 17).

In unit two, students showed growth with their own conversations. They practiced consensus-making with each other in whole-class dialogue. Student only (ST) segments tended to have more of a purpose. However, they still needed support with moving their ideas forward. Table 4.19 is an example of a ST episode in the middle of the 2nd unit.

Table 4.19 Transcript of a ST Episode in the Middle of the 2nd Unit where Consensus-making Instances Occurred

Line	Time	Person	Transcript
2712	2:17	Stephen	Well, um, I think Thomas's idea is actually possible. Because if water came in it might sort-of push the red dye out of the tube or **I agree with Thomas** in the end.
2713		Thomas	I am not sure if my ideas are as logical as they could be, but it seems it could make sense.
2714		William	Well, it's
2715		Thomas	I have no idea how that the water would get in more than the dye I am just saying that it could happen. It sees to me the most logic idea we've had yet though.
2716		Randy	The only idea we've had yet.
2717		Students	[yeah]
2718		Jared	Yeah, the only
2719		Thomas	**Gail, do you agree?**
2720		Gail	[mumbles or nods yes or no off camera]
2721	3:10	Thomas	**Why?**
2722		--	[21 seconds of wait time]
2723	3:31	Teacher	Quiet on a Monday morning. We talked about Monday mornings on Friday. So an idea was started out. Why don't you talk about it in your groups. What do you think about it?

Note: [2nd Unit, December 20 Video, Transcript, Lines 2711 – 2723, Time 2:17 – 3:47]

In this conversation Thomas had a novel idea for the group about what might have happened to the red dye with the egg. Stephen agreed with Thomas. Others realized it was a good idea to move forward. Thomas even "called out" Gail if she agreed with his idea and asked why she did/didn't. But after 21 seconds of wait time Gail did not respond to the why question and no other student joined in on that Monday morning. The teacher then asked them to talk in their groups about the idea (line 2723). Group chatter was strong for three minutes. During that time the teacher talked with most of the groups. In the one group the teacher can be heard saying "does that seem logical" (December 20, Field Notes). At the end of these three minutes the intensity of the conversation by the students diminished. The teacher then talked with the students about their other experiments and then asked them to talk in their groups if those results were similar or different than the red dye experiment. Eventually they wrote up ideas from these conversations for the claim and evidence presentations.

There were some episodes of thinking through (TH) ideas in each unit involving consensus-making. In the following two episodes students were working on trying to reach consensus on student-generated models that were on the board. In a pre-unit episode (Table 4.20) the students were all sitting at their desks arranged in four clusters and the teacher began talking close to one group, then moved toward another, then stayed close to the board. The teacher over the course of 64 seconds tried to get the students to agree on whether their model design should be kept. About half of the students were in and out of facing the front and "sitting and staring" similar to how the teacher described them early in the school year (September 22 Interview, Line 13). Students, when talking, were quietly talking to the teacher, making it hard for classmates to hear. Other students rarely turned to listen when a classmate spoke. When the whole-class was asked by the teacher if they agreed only a few heads nodded. This example includes ten coded consensus-making instances. Students were individually called on to hear the agreeability of the idea (sai), students were reminded to justify/support their agreement (sju), the students were being recognized by the teacher to agree/disagree (sad), and students were asked to reach whole-class for consensus (ccs). Additionally, the teacher either repeats what the students said or paraphrases what was said after every turn of student talk (See lines 954, 965, 971, and 975). The conversation was being shaped through asking for individual agreement and repeating ideas of the students.

Table 4.20 Transcript of a TH Episode in Pre-unit where Consensus-making Instances Occurred

Line	Person	Transcript	Consensus Code
952	Teacher	Do you agree with that Holly?	sai
953	Holly	No	
954	Teacher	you don't agree with him?	sad
955	Teacher	why not?	sju
956	Holly	[mumbles - not transcribed]	
957	Teacher	you just felt like disagreeing with him. Ok	
958	Teacher	remember we said one of our rules is that	tra
959	Teacher	we have to able to support why we agree or disagree.	sju
960	Teacher	why do you agree or disagree?	sju
961	Teacher	You need some time to think about it?	
962	Holly	[head nods]	
963	Teacher	AJ?	
964	AJ	The tube has four holes	
965	Teacher	The tube has four holes. so you are saying	
966	Teacher	that doesn't help us understand.	
967	Teacher	Ian, what do you think about that one?	sai
968	Teacher	would that data help us understand	
969	Teacher	that the strings are connected?	
970	Ian	not really	
971	Teacher	not really, so that's one that not really going	
972	Teacher	to hold a lot of stuff a lot of evidence.	
973	Teacher	does everyone agree that we should cross that one off?	ccs
974	Many	[students heads nod]	
975	Teacher	I see some heads nodding.	sad
976	Teacher	Holly why did you disagree with AJ?	sai

Note: [Pre Unit, August 30 Video, Transcript, Lines 952- 975, Time 9:21 – 10:25]

In a 2nd unit episode (Table 4.21) the students were all sitting at their desks arranged in four clusters and the teacher was in front of the room with Keith (a student). Three models on the board demonstrated the way that forces act on the human lung. All of the students were facing toward the front. When Thomas talked immediately before this episode started, many turned and faced him as he talked. Thomas talked about the ways in which movement was forced by something else. The teacher began the 51 second episode suggesting they did not get too complex with forces. This episode included three coded consensus-making instances for whole-class consensus (ccs). When

Table 4.21 Transcript of a TH Episode in 2nd Unit where Consensus-making Instances Occurred

Line	Person	Transcript	Consensus Code
1759	Teacher	Before we get too complex can we back it up and say that movement happens in the direction of the bigger force?	
1760	Students	[several nod and shake their head]	
1761	Teacher	and **would we agree with** that statement.	ccs
1762	Students	[many head nods, and verbal yeses]	
1763	Thomas	If mass is not calculated into it, yes.	
1764	Teacher	OK. we could talk later about that. but we don't understand mass yet , do we? as a group. I am	
1765	Teacher	guessing. **Is that a correct guess**?	ccs
1766	Students	[many say yes]	
1767	Teacher	so let's leave that out of our equation right now. so if I push on Keith more than he pushes what direction is he going to go?	
1768	Students	[many say back]	
1769	Teacher	so He's going in the direction of the bigger push. so if he pushes on me more on me than I on him, I'm gonna go this way. {teacher motions}	
1770	Students	[yeah] [a few head nods]	
1771	Teacher	so **would you agree that** my movement is gonna happen in the direction of the greater force.	ccs
1772	Students	[yes, yeah, head nods]	

Note: [2nd Unit, December 13 Video, Transcript, Lines 1759 – 1772, Time 19:39 - 20:30]

Thomas agreed with reservation (Line 1763) without the teacher calling on him the teacher quickly got the class to agree not to consider Thomas' idea and then helped the students to agree quickly about movement in the direction of the greater force. Thomas' voice was easily heard by the video camera from across the room. The teacher did not repeat what the students were saying nor did the teacher call on individual students to get their agreeability. For the most part either gestured or said agreement as a class to each (ccs) instance.

Overall, in this 2nd unit example, engagement with the models and consensus episode seemed high. In the pre-unit example, engagement with the models and consensus seemed to be pushed through by the teacher like the conversational "tug-of-war" he described the class having early in the school year (September 22 Interview, Line 13).

Table 4.22 Explanation of Codes Used for Figure 4.17

Code	Description of Code
Ccs	Teacher asked class consensus of student idea (e.g. "how many say" "show of hands" , "yes/no" type question
Sad	Teacher recognition of student agreeing/disagreeing (e.g. "x agreed so", "I heard", "you all agree", "I am hearing")
Sai	Teacher called on a student to hear agreeability of idea (e.g. "x do you agree?", "what do you think")
Tra	Teacher reminded students of their past consensus (e.g. "we said", 'you all said")
Sju	Teacher asked a student justification for agreement (e.g. "why do you agree", "why did", because?")
Rsa	Teacher reminded students class needs to reach consensus or agreement (e.g. "talk to them",
Tad	Teacher agreed or disagreed with student idea

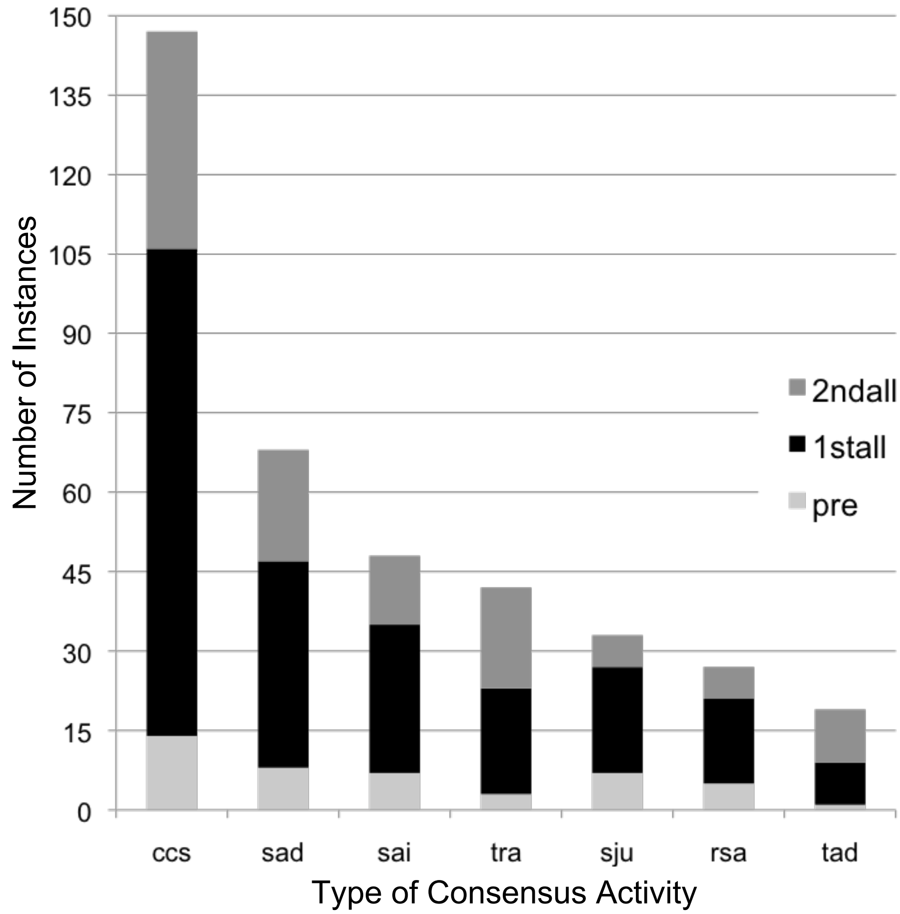

Figure 4.17 Number of instances where teacher was reinforcing a consensus activity.

In considering all segments of time and all instances of reinforcing consensus activity, as time went on consensus was less (see Figure 4.17 and Table 4.22). Asking for whole-class consensus of a student idea (ccs) occurred the most. The teacher recognizing students agreeing (sad), the teacher individually calling on a student to hear the agreeability of the idea (sai), and teacher recognition of a student idea (tra) were the next three most common reinforcing consensus episodes. These four types account for 79% of all instances of reinforcing consensus activity in this study.

The remaining 21% of reinforcing consensus types dealt with the teacher asking students to justify their agreeing (sju), the teacher reminding students that they needed to reach consensus or agreement (rsa), and finally the teacher agreeing or disagreeing with a student idea (tad). In the case of (sju) it was unclear as to why there were not more episodes asking for justification given that justification is closely tied to reasoning and evidence in science argumentation. However, one reason for the lack of sju episodes might have been because sju coded episodes often occurred before a student only (ST) or small group talking episode. The teacher might have been more likely to listen for and hear justification of an idea in student only talk or in group work. This effect may have reduced the need to ask students directly for it in whole-class dialogue. In the case of (rsa), students were not reminded that often to reach consensus on their own because often consensus episodes occurred during TW or TH episodes. In TW and TH dialogue consensus can be thought of as part of the process rather than separate from it. When students were asked to reach consensus on their own most of the time was spent in ST and group conversations and that data were not gathered for this study. Lastly, the teacher rarely agreed or disagreed with a student idea (tad), and when the teacher did agree/disagree it usually occurred during the beginning of each unit when students were deciding questions that could be testable and researchable. The teacher realized that a testable question must have been something he had thought of ahead of time. The teacher stated early in the first unit after a lesson in which the class was deciding testable and researchable questions,

> I'm negotiating with them, so I don't know that I can necessarily play the trump card in this is what I think, but at times I will say I've got something...if it's a testable, in order for me to put it there and be okay with what the class is saying, that means I've gotta have something kind of thought out ahead of time.
> (September 2 Interview, Line 40)

Additionally, consistent with characteristics of fostering dialogue, the fact that the teacher held back feedback by not agreeing or disagreeing with student ideas would likely account for the lack of rsa codes and further foster a *lack of* IRE and IRF cycle of classroom talk.

In summary, as the teacher's use of reinforcing consensus instances went down there were increasing instances of students engaging with the whole-class conversation. In later whole-class conversations students expressed agreeability without necessarily being asked. Some students were asking other students if they agreed as well. These student practices that developed over time also lessened the need for the teacher to ask for consensus. These findings support the claim that the teacher used less reinforcing consensus activities as time went on and that student use of consensus activities in these classes became more apparent in whole-class conversation as time went on.

Second Finding

Second Finding: Classroom engagement in critique by the end of the second unit was still under development. The teacher described critique as agreeing/disagreeing and telling why but did not use the word critique with students in any video analyzed in this study.

In Ford's (2008) notion of science learning, critique plays a vital role in appropriately helping the student to understand connections as knowledge was constructed. In this study the teacher sees one form of critique to be "agreeing/disagreeing and telling why". In an August 25th interview, as the school year was just beginning, he was asked about the ways in which he developed critique in the classroom. He said:

> It's kinda that - not words that I used a lot with them. It's just what they start doing. They're sharing ideas and they're disagreeing. So they're disagreeing, they're telling why, so they're doing a form of critique...as they are adopting other peoples ideas and changing, they're really constructing...They're critiquing themselves as they do it as well. So both private and public.
> (August 25 Interview, Lines 89-93).

As the first unit progressed the teacher described critique by the students as slow to develop and generally "superficial". In a September 1st interview he described students' ability to critique. He said,

> Very superficial critique. So they're not providing evidence, but they're saying 'no I don't think that happens', but they're not saying why. So, I don't know, I don't really think that's critique. They're just disagreeing. But I wasn't asking them to provide evidence for what they know either.
> (September 1 Interview, Line 30).

Being able to critique without a constructed understanding of another's idea is difficult. In a lesson on September 3 (1st Unit, September 3 Video, Transcript, Lines 1664 - 1819, Time 0:43 - 12:47) (See Appendix D) the class was trying to decide if 'wind' was living or not living based on the criteria they were using. They were all in a large circle behind their desks. The teacher was also sitting at one of the student desks. Ian thought that wind was living. In a thinking through (TH) episode the teacher interjected and asked "so based on our rules, we said it has to breathe or grow. So does it do one of the two?" (Line 1676). Many students then said it did not breathe or grow or need water. A few moments later Randy asked the class "who is disagreeing?" No one said they did. Then Randy asked the teacher "What's your opinion?" The teacher giggled and said "you're calling me on the carpet Randy" and quickly said to the class "I'm asking, is it living or were we not putting it the living category" (Line 1694). Deb loudly said "We are not putting it in the living category". The teacher said "Deb can't decide for everyone, how many of you say it is not in the living category?" All hands went up except for Ian's. Deb saw this and asked "Why do you [Ian] want it to be living?" (Line 1701). Ian said "it moves." Deb objected and Thomas began to talk to others about hot and cold air movement for about 20 seconds. The teacher then stopped the conversation and talked to them and said:

> Thomas, I like that you're willing to share and talk about your ideas. However, part of the negotiation too is not just talking to people, asking them why they think that. So, you said [referring to Ian] because it moves. Right, so because wind is moving. Why does that make it living? So maybe you [referring to the class] can ask him [Ian] to say his whole point of view and then that will help you to understand where he's coming from. Does that make sense?
> ([1st Unit, September 3 Video, Transcript, Lines 1711 - 1715, Time 0:43 - 12:47]).

Then Randy quieted the class and asked Ian "Why do you think it's living, Ian?" Many students turned to listen to what Ian was about to say. Ian said something briefly (too soft to hear on tape) and then many students talked without much focus about the issue for 50 seconds. The teacher stopped the conversation again. He said:

> OK. I am going to stop you again with your negotiation. I am excited today that you are willing to talk, but I am going to transition you from what you are doing, to what will be a little more productive. Alright, remember when I said you need to get his point out, and focus on where he's at not where you're at. Because you're trying to work with his idea. He's not caring about what you are saying, because he heard you this first time when he changed your mind. OK you're trying to work with his idea right. So, where do you need to keep coming back to? [Thomas says "asking him questions"] asking him questions not talking at him, because he was just sitting and letting you talk at him and he really doesn't really care. I am assuming right now. I, I really don't know. But I assume that is what you are doing. OK.
> (1st Unit, September 3 Video, Transcript, Lines 1725 - 1735, Time 0:43 - 12:47)

The class then made another attempt lasting about 60 seconds to persuade Ian of their ideas. The teacher started another TH episode, and asked "So Ian, what is wind?" The teacher then wove a conversation getting Ian to express his understanding. A few students added some support to the teacher's probing. At the end of the two-minutes episode Ian said wind was not living. The teacher then told the class, "Hopefully you are listening to what I just did with him. Did you hear how I questioned him? Talk with your neighbor what I did with him and how that is different than what you were doing with each other" (1775 - 1777). The teacher then briefly asked the class to talk about what he did and then he summed up what he thought he accomplished. He then told them:

> One thing I don't know if you picked up on...I looked back to his decisions he had made before. Why he had made those decisions. I think the big one for him it was the fire deal. He made a decision that fire was...not living. I remember part of that conversation was that a fire moves but that doesn't mean it is living. Air is moving so what does that mean? It doesn't mean it is living does it? So pulling in past conversations and past things people talked about. How important is listening?" [students say: "really important", "really really important", "most important thing after giving your opinion"] It's very important for negotiation. I just wanted to stop

> and make that point" (1st Unit, September 3 Video, Transcript, Lines 1815 - 1819, Time 0:43 - 12:47).

The class then agreed that wind was non-living. In this example, he encouraged the class to construct and understanding of Ian's idea so they could critique the points Ian was making. After several attempts the students were not successful in this endeavor without the teaching thinking through (TH) this with Ian.

A few weeks later (September 15) the teacher was asked about how classroom critique was progressing. He said, "It's still something that's awkward for them to do, but I think that's normal for this time of the year." In a follow-up question he was asked what differences he could expect to see down the road. "As it changes they're going to pick it apart quicker and faster, there'll be more point to what they're saying to disagree with" (September 15 Interview, Line 6).

On October 4 the teacher was again asked about how critique in the class was progressing. He said:

> I think we're still very superficial with what we're doing. The transformation I'm hoping to see is from what we had into - I read it, I read it, I assess it, I tell you what I agree with, I tell you what I don't agree with and my reasoning." We go back and forth, we're done, we move on. Instead of a half hour goes by and we're still with one person and 'I agree with that, I agree with that.' Or 'I disagree with that, what do we now think?'...There's got to be engagement both ways. So if I'm a group up presenting, I'm presenting to get critique, not just to watch you critique" (October 4 Interview, Line 4-6).

He also commented on his need to talk with his students about the ways in which to engage with critique. "Part of the discussion too will be, I've got to call you out because I'm critiquing that's going on...I'm looking to keep pushing you until you can get it. If you can't, then you've got to say, 'I don't know', 'I just made it up,' or 'Just an idea I had', 'I'm not sure I can support it'. But not to keep changing and jumping" (Line 11). He adds, "they get frustrated and they don't know how to deal with it [critique]" (October 4 Interview, Line 12).

Table 4.23 Transcript of a ST Episode in the Middle of the 2nd Unit

Time	Person	Transcript	NOTE
6:32	Thomas	How come your heart needs to keep up with your body. Thought it was inside of you so it wouldn't be left behind.	Disagree plus why
	Grace*	That's what I thought too.	
	Amber*	Well, we were trying to say it has to keep up with, well, not like right behind you. but like, keep up by beating faster. Like if you are running faster your heart is beating faster.	
	Grace	(interrupting Amber) The cells getting nutrients.	
6:58	Teacher	So are you talking about keeping up with the body or the body's needs?	
	Grace	(after a six second pause) well, we're kinda talking about keeping up.	
	Amber	But I guess we could change our words how we said it. Keeping up with.	
	Deb	Hum, I don't that agree that this episode had mostly the same needs as students. I think they do have the same needs because we students are make up of cells.	Disagree plus why.
7:34	Amber	OK. We can change that.	
	Scott	Does everyone agree with what Deb just said?	Student consensus
	Students	Many say yes.	
	Thomas	Also thinking about how the cells that the cells are needing more nutrients, water, and oxygen. I am not certain they're are actually needing more so, if you can tell me how you would how you would know that.	Disagree plus how
8:02	Amber	Can you talk a little louder Thomas?	
	Thomas	It's saying that cells are using more nutrients, water, and oxygen. I wouldn't actually, I don't actually know if that is true or not. But, it would make sense, but I would actually like to know how you knew that.	
	Amber	(after a 11 second pause) Any more questions?	
8:32	Janet	On your own graph, hum, did you guys all every, did you guys, like, [mumbles] does every color stand for the one you guys did?	
	Amber	Yeah it's average of each person	
	Randy	So did you do it twice? or did you change something?	
	Amber	We did it three times and averaged it. The person. [mumbles something]	
	Randy	Maybe we should look at their claim and see where it's at.	
9:09	Clarice	Yeah	

Note: [2nd Unit, January 14 Video, Transcript, Lines 3150 - 3171, Time 6:32 – 9:09]

* Grace and Amber are presenting.

During the end of the 2nd unit students seemed to be able to agree/disagree and explain their reasons. Table 4.23 includes an example of a transcript on January 14. The class had just completed some experiments on heart rate and were presenting and sharing their finding with the class. The conversation that followed the presenting group included three very clearly articulated agreeability moments, with each student being able to explain why or what they wanted to see expressed or revised. The conversation clearly indicated that they were listening to each other's ideas. The ability for the group to even engage with the presenting group's idea without the group repeating it or the teacher guiding the group conversation should be seen as a strong indicator of the class's ability to construct, and understanding of the presenting group so that its agreeability could be discussed. The 2.5 minute conversation was focused around their assessment of the claim/evidence, and what elements they agreed/disagreed to and why.

In the 1st unit example i.e. if wind was living, the class took 12 minutes and had many different changes in type of talk patterns for consensus to be reached. They were talking over each other, losing focus, and were not able to understand Ian's point of view so there could be a shared understanding. In this late 2nd unit episode (Table 4.23), critique was far from superficial. Both presenting group and class were engaged, and they picked apart elements quicker and faster - much like the teacher hoped they would by this point in time. Although the presenting group (Amber and Gail) did respond to the first two critiques, the group did not respond to the idea suggested in the third one. After the third attempt the presenting group waited eleven seconds before asking if there were more questions. The lack of response by the group or a follow-up by other students in the class was a likely indicator that their skills with engaging in a back-and-forth critique were still under development by the end of the second unit.

In summary, the teacher saw agreeing/disagreeing and telling why as important, but recognized that it takes time for students to be able to do this on their own. These results indicate that indeed students engaging in critique cannot be isolated from the student's ability to understand another's point of view. In the first example, the class struggled with the problem of understanding Ian's ideas. Without the teacher's help they could not, after two attempts, understand Ian's point of view. In the second unit example, the class understood the presenting group's ideas the first time they were heard, and could provide to the group explanation for their agreeability.

Summary of Chapter

This study found that as time went on four critical factors influenced classroom interactions: (1) the teacher's interactions in whole-class dialogue became increasingly focused less on talking to (TT) students and more focused on thinking through (TH) ideas with students, while at the same time students dialogued more as time went on, (2) the teacher encouraged students to publicly express their ideas by purposefully talking with (TW) students about their ideas which seemed to help foster later student only talk (ST) and thinking through (TH) episodes, (3) the teacher usually withheld sharing his agreeability of student ideas. This occurred only 19 times in 23.5 half hours of analysis and represented only 5% of all consensus making activity, (4) the teacher initially in the pre-unit and first unit often asked students for their agreeability of ideas. As time went on students without prompting asked each other for agreeability of their ideas. Table 3.15 summarizes these critical factors.

Table 4.24 Critical Factors of Whole-class Dialogue and Consensus-making

Early in the 18 Weeks	Toward end of 18 weeks
Talking To (TT) students more often than Thinkng Through (TH) ideas with students	Thinking Through (TH) ideas with students, while students also dialogued more as time went on
Teacher encouraged students to publicly express their ideas by purposefully Talking With (TW) students about their ideas	Just as evident as earlier weeks
Teacher withheld sharing his agreeability of student ideas	Withheld the same as earlier weeks
Teacher often asked students for their agreeability of ideas	Students are more likely to ask each other for agreeability of their ideas

CHAPTER FIVE

DISCUSSION

Introduction

This chapter summarizes the findings of this study and then discusses the implications for the ways which this teacher's patterns of whole-class dialogue, approaches to consensus-making, and notions of critique may suggest for the teaching of argument-based inquiry, and what this may suggest about grasp of science practice. Finally, future research and limitations for this study are also discussed.

Summary of Findings

In summary, the findings of this study provide some insight into an experienced 5th grade science teacher's classroom practice in developing argument-based inquiry (ABI) through the approach of the Science Writing Heuristic (SWH). During the first 18 weeks of the school year, this teacher worked with 21 students who had never engaged in ABI to develop whole-class dialogue and refine whole-class dialogue to support student learning. The conceptual framework used in this study recognized that grasp of practice in science argumentation happens in and through dialogue.

The first research question for this study investigated the initial whole-class dialogue patterns established by a fifth-grade science teacher who engaged in ABI. The results from this portion of the study found that the teacher principally engaged in three forms of whole-class dialogue patterns with students; talking to (TT), talking with (TW), and thinking through (TH) ideas with students. In the beginning of this study, interactions among these patterns were initially constructed and talked about, but these initial interactions were the beginning moments of dialogue, argumentation, and grasp of practice. As time went on, the teacher's interactions in whole-class dialogue became increasingly focused on thinking through ideas with students, while at the same time students also dialogued more as time went on.

The second research question for this study investigated the ways in which the science teacher helped to refine whole-class dialogue to support the agreeability of ideas constructed over time. The results from this portion of the study found that this teacher persistently engaged with students in consensus-making activities during whole-class dialogue. These efforts also showed progress over time and became part of the students' own initiatives as each unit progressed. Additionally, the classroom during these first 18 weeks of the school year did not engage in critique and construction of knowledge necessarily like the community of science but rather used agreeing and disagreeing, and explaining the reasons for agreeing and disagreeing through purposeful dialogic interactions to construct a grasp of science classroom practice.

Discussion of Findings

Patterns of Talk

This study identified that this teacher was principally engaged in three primary types of whole-class talk with students; talking to (TT) students, talking with (TW) students, and thinking through (TH) ideas with students as time progressed. This portion of the study suggests that when novice students were helped with engagement in whole-class dialogue shifts occurred in the type of whole-class dialogue that included the teacher. These shifts from less TT to more TW and TH helped students to develop a more prominent extended voice in whole-class dialogue.

In this study the pre-unit involved the student's initiation into elements of argument-based inquiry. The teacher was heard talking to (TT) students 75% of the time, before and/or after every episode of student only (ST) talk in the pre-unit. In TT students the teacher chose to convey an idea before or after student turns of talk. This early focus on the TT pattern worked towards redirecting, refocusing, and shifting momentum of ST only talk that the teacher early in the school year referred to as students "voicing opinions" (August 25 Interview, Line 26).

As time went on, patterns of talk changed around ST talk. In the second unit, 75% of the time the teacher's dialogic interaction with students before and/or after these episodes involved the teacher thinking through (TH) ideas with students. The important detail here is that this would suggest that ST talk also took on characteristics more aligned to talk patterns of TH as time went on.

From the earliest moments in this study the teacher followed students' ideas during classroom discourse. Braaten and Windschitl (2011) note that this is a critical pedagogical skill in any science teacher's practice. In this classroom if students needed help in building the ways in which to practice science argumentation, dialogue, and/or negotiation the teacher primarily used TT episodes. If students needed help in getting their ideas out, the teacher used TW episodes, and when they needed help in scaffolding their skills (Cavagnetto, Hand, & Norton-Meier, 2010) and thinking about matters related to the big idea he used TH episodes. Each of these talking patterns helped students to begin to take on the skills of following each other's ideas and the ideas of the community of science. In talking to, with, and thinking through ideas with students, the students were able to hear and practice the ways in which thinking can be traced. As time went on, time spent on TW, TH, and ST episodes would indicate that students became more capable of tracing their own thinking. In TW episodes students were given ample practice at expressing and hearing ideas in ways that Nystrand et al. (2003) defined as dialogical bidding. These ideas could be used later to build dialogue in ST and TH episodes that became more prominent over time. This pairing of TH and ST patterns that occurred 75% of the time in unit two suggests that these students were able to articulate and elaborate on their cumulative sense of understanding of their own and each other's points of view.

Similar to Kuhn and Reiser's (2004) and Brown and Kennedy's (2011) findings, overall thinking became a more collective process as the classroom connected their ideas in TH and ST episodes. In part, for the teacher to be TH ideas with students suggests that the student themselves expressed ideas that merited being thought through. As TH episodes unfolded around ST dialogue the teacher could also help students more fruitfully to examine the disciplinary ways in which science talks about the classes' big idea (Scott, Mortimer, & Aguiar, 2006).

Consensus-Making

This study also identified that the teacher placed importance early in the school year on helping students share their ideas and their agreeability of other students' ideas, while placing far less emphasis on students justifying those ideas. Additionally, the teacher rarely shared his agreeability of those same ideas. This portion of the study also suggests that early and persistent opportunities to engage novice students in agreeability of their own ideas in science as they emerge seems to foster, as time progresses, student generated initiatives towards consensus-making of questions, claims, evidence, and ideas.

In the pre-unit and beginning of the first unit (which occurred back-to-back) the teacher asked students for consensus many times, and represented 45% of all consensus instances coded in this study. Through this persistent activity early in the semester with students the teacher believed this to be an emergent form of engaging students in critique. In the initial interview with this teacher he clearly articulated that learning through negotiation means that in order to construct knowledge you must engage in critique. Although this teacher never used the word critique during the 23.5 hours of video used for this study, consensus activity was initially strong, over time persistently used, and eventually evident in student talk.

"Agreeing and disagreeing and telling why" was how the teacher described critique to this researcher. Fuenmayor (1990) points out that critique in the vernacular does not carry the same notion of critique by the community of scientist. Interestingly, the research literature discussing science argumentation values the component of critique but is silent in the ways in which one goes about introducing and developing critique with novice students. What this study unveils is that engaging novices in critique may not be principally the ways in which the community of science defines critique.

The teacher, after being given a copy of the results section (for member checking) was concerned by the detail that this researcher noted that he did not use the word critique with students. During the member check debriefing with the teacher he explained in greater detail what he saw as the steps for students agreeing/disagreeing and telling why in his classroom. He said that students determined: (1) if there are matching ideas that "I" have in my own schema (2) if there are enough justifications to support the idea (3) if the justifications have a strong relationship, and (4) if there is a direct relationship of questions, claims, and evidence" (from member check debriefing, lines 55-57). From analysis in this study this teacher's consensus-making work rarely approached his second criteria, and this third and fourth criteria was not apparent from the analysis in these two units. As our debriefing continued he was asked if his students got to these four criteria in units one and two. He stated:

> In the beginning of the year the students are encouraged to simply agree/disagree. Challenging another's idea is new and uncomfortable to them. They start off doing what is natural - basing their agree/disagree (reject or support) only on their own schema. However, as the year progresses they begin looking deeper as they come to realize that their own schema is quite often scientifically incorrect. I don't think that the majority of the students did, no. By the end of the year it was only a large handful that were that advanced"
> (Member check debriefing interview, Lines 58-62).

Kuhn and Reiser (2004) suggest that consensus-making has a way of making ideas seems sensible to students, while van Lier (1996) suggests consensus-making promotes a common understanding. The focus in this teacher's classroom on consensus as "agreeing and disagreeing and telling why" seemed to help make ideas sensible to students, and did not seem to jeopardize the construction of understanding by students over time. This view of consensus-making as a way to promote common understanding seems closely linked to the ways in which shared ideas in TW episodes in this classroom were checked for agreeability, while the notion of ideas seeming sensible aligns to the ways in which ideas were thought through in TH episodes in this study. The lack of explicit use of critique in this study would suggest that early in the learning of argument-based inquiry the process of repeatedly using "agreeing and disagreeing and telling why" as they construct knowledge was a workable approach to helping students develop a grasp of practice of school science.

Grasp of Science Practice in This Science Classroom

Critique, as used by scientists, seeks to understand the extent to which components of one's argument (e.g. data, claim, and evidence) come together in ways that do not contradict nature (Ford & Forman, 2006). When one's argument is thought to advance our understanding of nature, new knowledge is constructed within the community of science. However, this process of claiming new knowledge by the community of science can happen only when they engage in dialogue from the earliest moments of setting up a research question to the time that the knowledge is claimed and the community tries to understand the broader implications of that new knowledge. Without dialogue among scientists, meaning cannot flow through, turn together, and refract on and with others (Bakhtin, 1984; Fosnot, 1996; Isaacs, 1993; Nystrand, et al, 1997). The community of scientist engages in dialogue because they understand that one's explanations of nature are jointly owned, shared, and present a common text that one can edit. But it is only through critique and knowledge construction that the scientific community reaches consensus on how they use language to explain nature.

In this study, the fifth-grade science classroom over the course of 18 weeks worked towards understanding the components of each other's arguments (questions, claim, and evidence) through their developing dialogical interactions. Their earliest dialogues in each unit began with setting up testable and researchable questions concerning a "big idea" in science. In setting up questions as testable and researchable, the classroom community assured themselves an opportunity to negotiate their responses (claims and evidence) to testable questions in the light of the ways in which the broader scientific community has responded to those similar or related questions. This negotiated process in this classroom meant that one's own ideas were compared and contrasted (or as the teacher in this study said agree/disagree or reject/support) to classmates' ideas and experts in the community of science, and unlike Berland and Reiser's (2009) concern about teacher dominated ideas during negotiation, this study found that ideas from dominant students or ideas voiced by the teacher were not held in higher regard during negotiation.

The classroom in this study became a working community that constructed understanding about each other's ideas by agreeing or disagreeing with presented ideas. The ideas held by students and presented in the classroom were for the benefit of advancing their *own* understanding. When ideas emerged that were not consistent with an experiment, one's own ideas, each other's ideas, and the community of science's understanding of ideas there were disagreements that fostered more dialogue (ST and TH episodes in unit 2) that sought to negotiate meaning that the classroom community could eventually claim as "taken-as-shared" (Fosnot, 1996, p. 30) knowledge.

The newly negotiated science knowledge by this science classroom community was not "new" knowledge for science because their knowledge gains were built from the already negotiated standards and benchmarks used by the broader community of science. In the community of science, newly negotiated knowledge is only "new" knowledge if it advances the science community's understanding of the ways in which it uses language to explain nature. However, this explanation of the ways in which the community of science advances knowledge through critique, construction, and consensus is not the same as that which was seen in this study.

The SWH approach, which was used by the teacher in this study, represents one approach to ABI and does not claim that classrooms using this approach would construct knowledge *for* science (Hand, 2008). Additionally, neither do the national standards, guidelines, or benchmarks suggest that constructing knowledge *for* is a goal of school science. But clearly students in this study were expected to construct knowledge within a community of practice about science ideas for themselves. Students dialogued about the "big idea" for many hours in this study with the teacher, without the teacher, in small groups, and in written works and reflections. The students did ask and experiment with their own questions, made claims, supported them with evidence but they did not construct knowledge for science. This then is what appears to be an important message learned from this study. The dialogic work and the emphasis on consensus-making supported by the teacher in this study were not to have students generate new knowledge for science *nor* for students but rather that through dialogue and consensus-making these students come to understand that their own expressions of science knowing is learned through agreeing and disagreeing and explaining why through purposeful dialogic interactions in and with language experiences in the science classroom.

Implications for Teaching

In terms of setting up whole-class dialogue in argument-based inquiry there are four important ideas from this study that should be thoughtfully considered by other teachers interested in adopting this practice. First, this teacher persistently traced students' ideas over time; second, developing argument-based inquiry takes significant time; third, no one pattern of dialogue represents the best approach to argument-based inquiry; and fourth, consensus-making activities aids students' thinking over time.

The first important practice by this teacher was the fact that he persistently followed students' ideas in all types of whole-class dialogue, and overall talked less than students did in whole-class dialogue. As each unit progressed this teacher focused on helping students to get their ideas out publicly. In doing this, students' ideas could be followed, developed, and explored overtime by the teacher and potentially by other students. The results from this study also suggest that listening to students and the ways in which they understand the “big idea” takes the majority of the teacher’s time. In this study, the teacher did take an active leadership role in students’ negotiations, but the principle activity by the teacher was listening to best guide students’ thinking through their ideas as time passed.

The second important point from this study showed that even after 18 weeks into the school year the classroom community was still grasping to understand more deeply elements of argument-based inquiry. While clearly patterns of talk and emphasis on consensus-making shifted over the 18 weeks, the classroom still needed the teacher’s leadership and practice in students helping other students to think through ideas and reach consensus. For a teacher new to argument-based inquiry, these findings suggest that moving a novice group of students toward more proficient practice in ABI is not something you do *to* students but rather something that is done *with* students.

The third important point is that no one pattern of dialogue represents the best approach to argument-based inquiry. However, this study does suggest that patterns of dialogue early in the school year may not be representative of later patterns of dialogue. In this study, early in the process of learning ABI, students needed to be guided through the process of thinking through their ideas and the ways in which to dialogue with each other about their grasp of science practice. As time passed, student-to-student dialogue in this study increased along with the teacher thinking through ideas with student. The important message here for other teachers engaged in argument-based inquiry is that as the students began to understand a grasp of science practice, dialogue progressed toward a greater focus on helping students think through their ideas not only in relation to each other but also in relation to how the community of science views those same ideas.

The fourth important point demonstrated that consensus-making fostered by the teacher in this study early and often in the school year appeared to be an important resource in helping students to express their ideas, understand each other’s ideas, and the ideas in the community of science. As time passed, students in this study asked each other more often for their agreeability of ideas. This shift toward students asking for consensus appeared to help students be attentive and accountable to each other's ideas. This appeared to strengthen student only talk and the teacher thinking through ideas with students, because classroom community had a greater understanding of one another's thinking.

Through analysis of this experienced teacher's fifth-grade classroom, this study also provides some important overarching implications for developing whole-class argumentation practices in elementary science classrooms: first, about engagement in argue-based inquiry; second, about embedded versus explicit instruction of argument-based inquiry; finally, about curriculum and approaches to argument-based inquiry. First, the data collected from this science classroom always showed the classroom engaged in some aspect of ABI, and that this approach was not casually or selectively used for some of the science curriculum. Rather, ABI was the way science was practiced in that classroom. In consideration of the findings, even after two units of instruction (about 80+ hours) with novice students of argument-based inquiry, progress toward mature whole-class dialogue, consensus-making, and justification of ideas was still being refined and developed. This persistent classroom practice could serve as an important reminder that argument-based inquiry takes time to develop and needs to be the classroom's way of practicing science if it is to mature as time goes on. Second, the learning of ABI in this classroom was an embedded practice where skills of science argumentation were never taught outside of the context of the "big ideas" for the pre-unit, unit one, or unit two. Elements of learning science argumentation were always contextualized around whatever place students were with the "big idea". While this study is not suggesting that direct instruction in argumentation may not benefit students, there was no evidence in this study of direct instruction of ABI. Third, this teacher was not provided nor chose to use a prescribed curriculum. Rather this particular teacher used ABI to guide each standards-based unit's "big idea". The students generated their own questions, collected their own data, and provided evidence to support and refute evidence for the class's "big idea". In other studies (i.e. Erduran, Simon, & Osborne, 2004; Osborne, Erduran, & Simon, 2004; Simon, Erduran, & Osborne, 2006; von Aufschnaiter, Erduran, Osborne, & Simon, 2008) teachers were trained in the ways in which to use a particular curriculum in order to engage students in science argumentation. While this study is not suggesting that curriculums should not be provided to teachers, it is clear from this study that this teacher did not use a prescribed curriculum but rather used a standards-based "big idea" in science paired with the SWH as one approach to ABI to guide and support students as they learned to get a grasp of science practice.

Implications for Future Research

This study was conducted with a fifth-grade science teacher who had ample professional development and experience using the SWH as one approach to argument-based inquiry. However, it is not known how the results of this study would look given the same research questions with other teachers having similar experiences with the SWH approach or other approaches to argument-based inquiry. Additionally, it is not known how these results would look if teachers with less experience or students with more experience in argument-based inquiry were to have been involved with this study. Replicating this study with teachers having similar or less experience or with students not as inexperienced with the SWH or another approach to argument-based inquiry could provide additional insights for the science education community.

A second need that comes out of this study is the ways in which other classrooms that practice argument-based inquiry use consensus-making activities to aid in their knowledge development in science. In this particular study, consensus-making was an important component of whole-class dialogue, while engaging in critique was described by the teacher as agreeing and disagreeing and explaining why. It is unclear from the present literature in science argumentation how a teacher using argument-based inquiry uses consensus-making and critique over time and to what extent either or both are used or seen as linked and/or related.

A third need from this study is to trace the ways in which students' dialogue may shift and change in group work as compared to whole-class dialogue over time. In the data set for this study, more than one-third of all students' talk happened in small group work. The effect is not known of the role that small group dialogue had on whole-class dialogue. Additionally, it is not known how or if patterns of whole-class dialogue may be evident in small group dialogue. Research looking simultaneously at whole-class dialogue and small group dialogue over time might provide insight into the ways in which students understand the grasp of science practice.

A fourth need from this study analysis beyond the first 18 weeks of the school year is to determine the extent to which patterns of dialogue, consensus-making, and critique shift continue to shift in this or similar classrooms. Looking at an experienced teacher's class over an entire year of instruction might provide far better insight into changes in patterns of dialogue and consensus-making found in this study.

Limitations of this Study

Several limitations of this study stem from the initial research questions, setting of the study, and the methods used. First, this study represents one experienced teacher's use of the SWH as one approach to argument-based inquiry in one Midwestern USA fifth-grade classroom. Clearly the results of this study are not generalizable as to how other teachers might have engaged students given the same instructional setting and situation. This study was one teacher's way of practicing argument-based inquiry. Other teachers with more or less expertise may have provided far different results.

Second, this study's research questions considered only whole-class dialogue. In this study more than 1/3 of all student talk occurred in small group work, but was not examined to see its relationship to shifts in whole-class dialogue. This is a limitation because it is not clear of the extent to which small group dialogue influenced the development of whole-class dialogue or visa-versa. However, the design of this research study was focused on the teacher's role in helping to develop whole-class dialogue. In this study the teacher's dialogic work while students were working in groups was minimal, as noted from viewing recorded video or observing during on-site visits.

The third limitation for this study was that it only looked at 200 minutes of classroom activity in the first, middle, and end of each unit. Although this represented over 23 hours of this classroom's instructional time, the time between these segments may have provided important insight in the ways in which whole-class dialogue patterns and consensus-making occurred in this teacher's classroom. The decision to use only these time slots was appropriate given that both units of instruction were patterned after the same instructional approach and enabled parallel looks at two units over time.

A final limitation for this study was that dialogue was more than just spoken words in this classroom. Dialogue in this study also took place through readings and writings. This study did not consider the documents that the teacher or students read or the work they wrote before or after moments of whole-class dialogue. Understanding what the teacher and students accomplished in private moments might have provided insight as to what or why they emphasized or stated certain things during whole-class dialogue. This limitation highlights the ways in which dialogue is dynamic and takes into account all past experiences, but those past experiences are not always clearly known during whole-class conversation.

APPENDIX A

SAMPLE GUIDED CONVERSATION QUESTIONS/DISCUSSION POINTS

Can you describe for me how you help to create a science classroom community.

Start of year…

several weeks into the school year…

by the second semester…

I would like to have a general conversation about PD.

What have your PD experiences in science done for you?

How has this PD impacted your science classroom?

How would you describe what you do to a teacher who is not familiar with your science classroom?

What challenges do you have as a science teacher?

What strengths do you have as a science teacher?

Which of these factors is the hardest for your support or implement? Explain why this is the case.

Please describe your thinking as you plan the science instruction for your classroom.

Describe what your previous experiences have taught you about establishing argument-based inquiry.

Please describe what instructional factors are involved as you go about modeling argument-based inquiry. Describe how you go about making changes to maintain strong support of argument-based inquiry.

Tell me about what you mean when you say…

Can you think of other things you would like to discuss about how you establish a culture of argument-based inquiry?

APPENDIX B

EXPLANATION OF CONSENSUS-MAKING CODES

Code	Description of Code
Ccs	Teacher asked class consensus of student idea (e.g. “how many say” “show of hands” , “yes/no” type question
Sad	Teacher recognition of student agreeing/disagreeing (e.g. “x agreed so”, “I heard”, “you all agree”, “I am hearing”)
Sai	Teacher called on a student to hear agreeability of idea (e.g. “x do you agree?”, “what do you think”)
Tra	Teacher reminded students of their past consensus (e.g. “we said”, ‘you all said”)
Sju	Teacher asked a student justification for agreement (e.g. “why do you agree”, “why did”, because?”)
Rsa	Teacher reminded students class needs to reach consensus or agreement (e.g. “talk to them”,
Tad	Teacher agreed or disagreed with student idea

APPENDIX C

EXPLANATION OF TYPES OF WHOLE-CLASS DIALOGUE

Activity	Code	Description
Teacher **T**alking **T**o students	TT	*Teacher talking to* students for a turn of talk that lasted usually more than 5 seconds. All students were asked or expected to be listening to the teacher. If student talk did occur during these moments it was infrequent and very short.
Teacher **T**alking **W**ith students	TW	Teacher was *talking with* students over several turns of talk (usually more than 15 seconds) to help students express or explain their student thoughts about a particular idea. The teacher was helping students to hear the ideas of their classmates. The teacher pointed out what is stated from student talk as well.
Teacher **TH**inking though ideas with students	TH	Teacher was *thinking through* ideas with students over several turns of talk (usually more than 15 seconds) to help students think through their understandings. The teacher mentioned ideas that might not have directly come from students or bring together ideas from the past that were mentioned by students.
Student only **T**alk	ST	*Student talking* to students over turns of talk that last usually more than 15 seconds. Students as a whole class talked to each other without the teacher talking.

Explanation of Types of non whole-class dialogue

Activity	Code	Description
GRoup work	GR	Students talked/worked in small groups. (not whole-class dialogue)
Indi**V**idual student work	IV	Students worked individually at their desks. (not whole-class dialogue)
Classroom **M**ovement	CM	Students cleaned, stored, or moved about the room between some other activity. (not whole-class dialogue)

APPENDIX D

CODED TRANSCRIPT FOR SEPTEMBER 3

Segment	Line	Words consensus	Type	CD	time
1st_beg	1651	===		LINES	
1st_beg	1653	{H_09032911b.mp4}		VIDEO	
1st_beg	1664	00:43 00:54		TIME	TH
1st_beg	1665	“How many of you say wind is living?	ccs	TEACHER TALKS	TH
1st_beg	1666	so, we have one, kind of.		TEACHER TALKS	TH
1st_beg	1667	why do you think wind is kind of living.	sai	TEACHER TALKS	TH
1st_beg	1668	00:54 - 3:17		TIME	TH
1st_beg	1669	[ST: many talk, something moves it, research it.]		STUDENT TALK	TH
1st_beg	1670	“well.”		TEACHER TALKS	TH
1st_beg	1671	[G: it moves because of the expanding and contracting by temperatures]		STUDENT TALK	TH
1st_beg	1672	[K: see because of the temperatures.]		STUDENT TALK	TH
1st_beg	1673	[G: warmer things would rise. warmer air would go upward and cooler air would fill]		STUDENT TALK	TH
1st_beg	1674	[its place.]		STUDENT TALK	TH
1st_beg	1675	[ST: mumbles]		STUDENT TALK	TH
1st_beg	1676	“so based on our rules, we said it has to breathe or grow. so does it do one of the”	tra	TEACHER TALKS	TH
1st_beg	1677	two?		TEACHER TALKS	TH
1st_beg	1678	[STmany: it does not grow, just because of the temperatures. we don't grow because]		STUDENT TALK	TH
1st_beg	1679	of the temperatures. you can see it. it doesn't need to breathe. it doesn't need water		STUDENT TALK	TH
1st_beg	1680	to live.		STUDENT TALK	TH
1st_beg	1681	“the other part we said it was made of cells.”	tra	TEACHER TALKS	TH
1st_beg	1682	[STmany: Air is not made of cells. but it is kind of made of molecules. well, their like.]		STUDENT TALK	TH
1st_beg	1683	anything in existence is a molecules. every type of. wind is a molecules, but not		TEACHER TALKS	TH
1st_beg	1684	cells.		TEACHER TALKS	TH

1st_beg	1685	[R: who is disagreeing?]		STUDENT TALK	TH	
1st_beg	1686	{NOTE: Student asks for agreeability}		NOTE	TH	
1st_beg	1687	K: everything and everyone is made of molecules but wind but wind is not made of		STUDENT TALK	TH	
1st_beg	1688	cells.		STUDENT TALK	TH	
1st_beg	1689	2:53		TIME	TH	
1st_beg	1690	"I don't understand this molecules stuff."		TEACHER TALKS	TH	
1st_beg	1691	[R: what's your opinion]		STUDENT TALK	TH	
1st_beg	1692	[STk: molecules are little things that are]		STUDENT TALK	TH	
1st_beg	1693	"you are calling me on the carpet R.		TEACHER TALKS	TH	
1st_beg	1694	I'm asking is it living or are we not putting it the living category.	ccs	TEACHER TALKS	TH	
1st_beg	1695	[STk: we are not putting it in the living category because wind it.]		STUDENT TALK	TH	
1st_beg	1696	"K does not want to put it in the living category .	sad	TEACHER TALKS	TH	
1st_beg	1697	she can't decide for everybody."	rsa	TEACHER TALKS	TH	
1st_beg	1698	How many of you say it is not in the living category.	ccs	TEACHER TALKS	TH	
1st_beg	1699	[all hands but one go up E's]		STUDENT TALK	TH	3.25
1st_beg	1700	3:17 - 4:06		TIME		
1st_beg	1701	[STk: E, why do you not want it not to be in, why don't you want it to be]		STUDENT TALK	ST	
1st_beg	1702	yes it moves but , we do not move because of temperature. unless you are like a		STUDENT TALK	ST	
1st_beg	1703	bird. it doesn't need water to survive.		STUDENT TALK	ST	
1st_beg	1704	[G: a not air balloon rises because the air inside is hot. which is lighter than all the]		STUDENT TALK	ST	
1st_beg	1705	other air which makes it go upward. when you let all the hot air it will go back		STUDENT TALK	ST	
1st_beg	1706	downward. and their is constant air filling another point. that's what wind is. going to		STUDENT TALK	ST	
1st_beg	1707	another spot that is empty?		STUDENT TALK	ST	0.75
1st_beg	1708	~		BLANK		
1st_beg	1709	~		BLANK		
1st_beg	1710	4:06 - 4:29		TIME		
1st_beg	1711	"G I like that your willing to share and talk about your ideas. however"		TEACHER TALKS	TT	

1st_beg	1712	part of the negotiation too is not just talking to people, asking them why they think	TEACHER TALKS	TT	
1st_beg	1713	that. so, you said because it moves. right so because wind is moving why does that	TEACHER TALKS	TT	
1st_beg	1714	make it living. so maybe you can ask him to say his whole point of view and then	TEACHER TALKS	TT	
1st_beg	1715	that will help you to understand where he's coming from. does that make sense?	TEACHER TALKS	TT	0.25
1st_beg	1716	4:29 - 5:35	TIME		
1st_beg	1717	{Students discuss without teacher}	NOTE		
1st_beg	1718	[STmany: so you think that wind is living. why do you think it is living ET? well we]	STUDENT TALK	ST	
1st_beg	1719	move it. somebody moves it. wind if its alive moves. It can move. every living thing	STUDENT TALK	ST	
1st_beg	1720	needs water to survive. air is a gas, not water. water does evaporate. so water is	STUDENT TALK	ST	
1st_beg	1721	kind of air. air doesn't need air cause it already has it.	STUDENT TALK	ST	1
1st_beg	1722	~	BLANK		
1st_beg	1723	~	BLANK		
1st_beg	1724	5:35 - 6:19	TIME		
1st_beg	1725	"OK. I am going to stop you again with your negotiation. I am excited today that"	TEACHER TALKS	TT	
1st_beg	1726	you are willing to talk. but I am gonna transition you from what you are doing, to	TEACHER TALKS	TT	
1st_beg	1727	what will be a little more productive alright. remember when I said you need to get	TEACHER TALKS	TT	
1st_beg	1728	his point out, and focus on where he' s at not where you're at. Because you're tying	TEACHER TALKS	TT	
1st_beg	1729	to work with his idea. he's not caring about what you are saying, because he heard	TEACHER TALKS	TT	
1st_beg	1730	you this first time when he changed your mind. OK you're trying to work with his	TEACHER TALKS	TT	
1st_beg	1731	idea right . so Where do you need to keep coming back to	TEACHER TALKS	TT	
1st_beg	1732	[asking him questions]	STUDENT TALK	TT	
1st_beg	1733	asking him questions not taking at him. because he is just sitting letting him sit and	TEACHER TALKS	TT	
1st_beg	1734	talk at him. and he really doesn't really hear. I am assuming right now. I really don't	TEACHER TALKS	TT	
1st_beg	1735	know. I assume that is what you are doing. OK.	TEACHER TALKS	TT	0.75
1st_beg	1736	~	BLANK		
1st_beg	1737	{NOTE: Here was talking to students about the pedagogy of negotiation. He is	RESEARCH NOTE		
1st_beg	1738	teaching his students how to listen and ask questions that will help to consider the	RESEARCH NOTE		

1st_beg	1739	position of another as ideas are negotiated for. Pushing your ideas on another for H		RESEARCH NOTE		
1st_beg	1740	means that you are not taking the ideas of the other person to reveal and build		RESEARCH NOTE		
1st_beg	1741	understanding.}		RESEARCH NOTE		
1st_beg	1742	~		BLANK		
1st_beg	1743	6:19 - 7:24		TIME		
1st_beg	1744	[students discuss wind/air]		STUDENT TALK	ST	1
1st_beg	1745	7:24 - 9:30		TIME	TH	
1st_beg	1746	"So E, what is wind?"		TEACHER TALKS	TH	
1st_beg	1747	[E:]		STUDENT TALK	TH	
1st_beg	1748	[mumbles]		STUDENT TALK	TH	
1st_beg	1749	"so its the air that is moving is wind? is that saying what you are saying? air"	ccp	TEACHER TALKS	TH	
1st_beg	1750	that's moving. is air by itself living?		TEACHER TALKS	TH	
1st_beg	1751	[E: no]		STUDENT TALK	TH	
1st_beg	1752	so the air around you right now is living. I am asking E. Is the air around you living.		TEACHER TALKS	TH	
1st_beg	1753	[E; yeah]		STUDENT TALK	TH	
1st_beg	1754	how is the air around you living?		TEACHER TALKS	TH	
1st_beg	1755	[D: look outside the trees are moving, and that they are not alive.]		STUDENT TALK	TH	
1st_beg	1756	E a little bit ago our conversation was a fire. how would you classify fire?		TEACHER TALKS	TH	
1st_beg	1757	living or not living		TEACHER TALKS	TH	
1st_beg	1758	[E: not living]		STUDENT TALK	TH	
1st_beg	1759	not living		TEACHER TALKS	TH	
1st_beg	1760	[STmany: yeah but it moves]		STUDENT TALK	TH	
1st_beg	1761	[flame of the fire move you are saying the same thing about wind.]		STUDENT TALK	TH	
1st_beg	1762	So E you said a fire is not living and it moves		TEACHER TALKS	TH	
1st_beg	1763	but yet the air is moving so it has to be living?		TEACHER TALKS	TH	
1st_beg	1764	[chatter SHHHO, listen]		STUDENT TALK	TH	
1st_beg	1765	[E: I guess mumbles]		STUDENT TALK	TH	

1st_beg	1766	OK I am not making you change your mind.	rsa	TEACHER TALKS	TH	
1st_beg	1767	I will ask you again, is air living?	sai	TEACHER TALKS	TH	
1st_beg	1768	[E: no]		STUDENT TALK	TH	
1st_beg	1769	so just because the air is moving more does that make it living?		TEACHER TALKS	TH	
1st_beg	1770	[no]		STUDENT TALK	TH	
1st_beg	1771	OK.		TEACHER TALKS	TH	2
1st_beg	1772	~		BLANK		
1st_beg	1773	~		BLANK		
1st_beg	1774	9:30 - 9:36		TIME		
1st_beg	1775	"Hopefully you are listening to what I just did with him. Did you hear how"		TEACHER TALKS	TT	
1st_beg	1776	I questioned him. Talk with your neighbor what I did with him and how that different		TEACHER TALKS	TH	
1st_beg	1777	than what you were doing with each other.		TEACHER TALKS	TT	0.1
1st_beg	1778	~		BLANK		
1st_beg	1779	9:36 - 10:09		TIME	ST	
1st_beg	1780	[students talk with neighbors]		STUDENT TALK	ST	0.5
1st_beg	1781	~		BLANK		
1st_beg	1782	~		BLANK		
1st_beg	1783	10:09 - 11:36		TIME	TW	
1st_beg	1784	"OK I don't want to spend a whole lot of time on what I was doing with him."		TEACHER TALKS	TW	
1st_beg	1785	but what did you notice I was doing that was different than how we had operated.		TEACHER TALKS	TW	
1st_beg	1786	let's use hands for this so we can go a little more pointed. Yes.		TEACHER TALKS	TW	
1st_beg	1787	[T: what you, that you didn't , you asked him questions and he said something. You]		STUDENT TALK	TW	
1st_beg	1788	said you weren't trying to change his mind. because...		STUDENT TALK	TW	
1st_beg	1789	"So I wasn't forcing him to change his mind. I was not forcing his arm. Ok what"		TEACHER TALKS	TW	
1st_beg	1790	else did you notice. R?		TEACHER TALKS	TW	
1st_beg	1791	[R: you persuaded him?]		STUDENT TALK	TW	
1st_beg	1792	"I persuaded him?"		TEACHER TALKS	TW	

1st_beg	1793	[R: No, never mind. If I think of it .]	STUDENT TALK TW
1st_beg	1794	"OK i can come back to you. G?"	TEACHER TALKS TW
1st_beg	1795	[G: You questioned him about everything that you thought. until you had exactly]	STUDENT TALK TW
1st_beg	1796	[what you thought]	STUDENT TALK TW
1st_beg	1797	"I got to the root of his idea so I kept coming back to what and where his idea was"	TEACHER TALKS TW
1st_beg	1798	at. right? OK. B?	TEACHER TALKS TW
1st_beg	1799	[Stb: um, well you were, you were kinda not yelling a bit. you were talking a bit]	STUDENT TALK TW
1st_beg	1800	[calmly] and mumbles.	STUDENT TALK TW

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