Secondary Science Teachers' and Students' Beliefs about Engaging in Whole-Class Discussions

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SECONDARY SCIENCE TEACHERS’ AND STUDENTS’ BELIEFS ABOUT ENGAGING IN WHOLE-CLASS DISCUSSIONS

Dissertation
by
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Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

December 2012
ABSTRACT

Secondary Science Teachers’ and Students’ Beliefs about Engaging in Whole-Class Discussions

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Reform movements in science education have repeatedly called for more dialogic and student-centered discussions during science lessons. The approach secondary science teachers take towards talk during whole-class discussions continues to be predominantly teacher-centered even when curriculum materials are designed to support a shift in discourse. This dissertation explores what factors may be influencing the approach that both teachers and students take towards whole-class discussions in order to understand why the type of talk that occurs in high school science lessons is not changing.

In order to achieve a more comprehensive understanding of this issue, this dissertation made use of mixed methodology. To explore secondary science teachers’ beliefs in general, responses to a statewide survey of science teachers (N=185) were analyzed statistically to investigate factors that were related to their efficacy beliefs about whole-class discussions, as well as their beliefs about the effectiveness of dialogic and authoritative approaches to bring about learning in students. Acknowledging that discursive interactions are context dependent, a case study of a high school chemistry teacher and her students (N=45) was also included which examined both the teacher’s
and her students’ beliefs as well as how those beliefs manifested themselves during instruction.

Findings suggest that although teachers believe that a dialogic approach to whole-class discussions is more important for student learning than an authoritative approach, lower self-efficacy for engaging in dialogic talk is related to limited opportunities teachers have to learn and recognize alternative strategies that can be used to shift talk during whole-class discussions. Furthermore, school and student characteristics may play a role in teachers’ beliefs about the effectiveness of dialogic talk as an approach to learning science. The teachers’ role is only one part of the interaction, however. This dissertation also shows that secondary students have beliefs and expectations about whole-class discussions that also influence the type of discourse that can occur. Changing the type of talk that occurs in high school science classes will require not only professional development about talk strategies for teachers, but also a shift in how students frame their role in discussions and the purpose of talk in learning science.
For my parents and grandparents who immigrated from the Azores so that opportunities like this would be possible.

For my husband, Pedro, and my children, Alexander and Cynthia, for all their love and support.
ACKNOWLEDGEMENTS

I began this journey in the doctoral program over five years ago as a way to understand my profession, or better yet my vocation, more comprehensively. As a result, my passion for understanding and improving high school science teaching has only grown. Along the way, I have had the opportunities to engage in thinking about the role of education with many people either through conversations or by reading their ideas. These interactions have transformed my understanding of what it is to be a teacher and what the role of public education is in our society. While I am grateful to anyone who has critically engaged me in theoretical and practical aspects of education, especially the professors of Boston College, there a several people in particular who have been instrumental in making this piece of work possible.

I am forever indebted to Dr. Katherine L. McNeill, a well-respected scholar in the field of science education. While doing research with her, I learned what it meant to apply the many quantitative and qualitative concepts I learned in my courses. I lack the words to adequately convey the importance of her guidance and encouragement throughout this entire process. Her dedication to the improvement of science education for all students is extremely strong. I am honored to have had the opportunity to learn from such a gifted academic and truly wonderful person.

I am also grateful that both Dr. Laura O’Dwyer and Dr. Lisa (Leigh) Patel agreed to be members of my dissertation committee. They were the yin and yang of my work. While my appreciation for the power and limitations of statistical methods came from my interactions with Dr. O’Dwyer, my respect for the role of qualitative research in
acquiring a more comprehensive understanding of the role of context in education came from my interactions with Dr. Patel. I have a deep and sincere respect for their academic passion and hope someday to have at least a fraction of the impact they have had in education.

While I am grateful to the administrators at my high school and all of my science department colleagues for supporting me in this endeavor, I am especially indebted to Ms. Romac (you know who you are) and her chemistry students. Thank you for opening up your classroom for my case study. Your willingness to share your beliefs and ideas truly made this dissertation richer. I hope that you realize that your words matter.

Lastly, I would like to thank the graduate students who helped me along the way. I am especially grateful for the help of Amanda Knight in coding the chemistry lessons and for our many conversations. I also take this opportunity to thank Jeremy Price, an exceptional science education researcher. Having you on this journey with me was truly a blessing.
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CHAPTER ONE: INTRODUCTION

“The man of even ordinary culture is aware of the rapid changes of subject-matter, and taught so that he believes subject-matter, not method constitutes science, he remarks to himself that if this is science, then science is in constant change and there is no certainty anywhere. If the emphasis had been put upon method of attack and mastery, from this change he would have learned the lesson of curiosity, flexibility and patient search; as it is the result too often is a blasé satiety” (Dewey, 1910/1964, p. 190).

When science was introduced into the public school curriculum, it was based on the merit of its ability to contribute to mental discipline with memorization of facts that could also be useful (DeBoer, 1991). Since that time however, many arguments have been made which call for a more authentic relationship between science education goals and the essence of the discipline. Dewey (1910/1964) conceptualized science education as a means by which students would be taught to think scientifically acquiring a “mental attitude” that placed reasoning, problem-solving and questioning at the forefront of their approach to knowledge. This approach has been championed repeatedly throughout recent years with such documents as the National Science Education Standards (National Research Council [NRC], 1996), the national report on science education titled Taking Science To School (Duschl, Schweingruber, & Shouse, 2007) and the most recent science education framework set forth by the NRC (2011), A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.

Given the explosion of scientific knowledge that has come about in the last century due to technological advancements, it is naïve to think that learning science today is merely a matter of knowing some strategic facts. For some students, K-12 science education opens the doors to white collar careers in fields which require previous
enculturation into domain-related approaches and language. More generally, however, K-12 science education is an important means by which to prepare all students to make personal and political decisions about science-related issues. These decisions are based on many assumptions which require knowledge that transcends mere factual information. The ability to approach science in a critical way, based on an understanding of the roles of evidence, reasoning, and ideas, instead of science as a compilation of truths ascertained by stepwise procedures is vital for informed decisions to be made.

Currently, the United States is lagging behind other nations in the effort to produce scientifically proficient citizens. For example, results from the Program for International Student Assessment (PISA) 2006 showed that the average score of 15-year-old students from the United States was significantly lower than the overall average of the other nations participating in the study (Baldi, Jin, Skemer, Green, & Herget, 2007). The test purports to measure students’ abilities to apply scientific knowledge by assessing the extent to which they can explain scientific phenomena and use scientific evidence within “real-life contexts” (p.3). These results of U.S. high school students are more disturbing given that they come many years after the National Science Education Standards (NRC, 1996) called for shifting the student science experience to one “that engages them in the active construction of ideas and explanations and enhances their opportunities to develop the abilities of doing science” (p. 121). While the performance of the United States students on the most recent PISA from 2009 improved such that it was not statistically different from the average, the United States still ranked lower than
18 other countries participating in the assessment including China, Japan, Finland and Germany (OECD, 2010).

Trends in National Assessment of Educational Progress (NAEP) scores also show a significant decrease in the percentage of U. S. students who can be considered proficient in science as one progresses from the elementary to the secondary levels (Grigg, Lauko, & Brockway, 2006). This report also states that student scores from the secondary level have significantly decreased since 1996. Significant gaps remain among White students’ scores and those of Black and Hispanic students. Also, in both elementary and middle school levels, those students who qualified for free or reduced lunch scored significantly lower in science than other students: 37% to 72% respectively for 8th grade students (National Center for Education Statistics, 2005). A clear focus on secondary science instruction especially that which is conducted with under-represented groups in science is important to explore.

Although curriculum designed to provide opportunities for students to engage in inquiry-based activities has been associated with significant gains in science achievement (Geier et al., 2008; Marx et al., 2004; White & Frederiksen, 1998), other studies have suggested modest to negligible differences can be attributed to such activities (Pine et al., 2006; Schneider, Krajcik, Marx, & Soloway, 2002). A main reason given for the inconsistent results is the variability that exists in teachers’ approaches to discussing science with students such that an in depth understanding of the practice can be achieved (Johnson, Kahle, & Fargo, 2007; Klahr & Nigam, 2004; Klahr & Li, 2005). Recent studies show that even when curriculum is written to support more active forms of
student participation in discussions about scientific concepts, some teachers are not shifting their approach (Alozie, Moje, & Krajcik, 2010; Puntambekar, Stylianou, & Goldstein, 2007).

Wheeler (2000) cautions that the types of activities that are being done in science classes are not as important as how these activities are being approached by the teacher and students. He suggests therefore that educators and researchers must also consider the types of questions that are being addressed and the discursive interactions that take place. Although the frequency with which a teacher engages her students in lab investigations or real-life applications may seem on the surface to be a vital factor in learning science, a distinction must be made between “doing the lesson” and “doing school” (Jiménez-Aleixandre, Rodriguez, & Duschl, 2000, p. 757). In the first case, the ultimate goal is to gain a deeper understanding of the meaning behind an activity, while in the second, the focus is on getting through the activity such that students are able to respond with the correct content answers. It is the dialogue that occurs during these lessons between the teacher and the students that essentially defines the type of learning that can take place (Mercer & Littleton, 2007).

Dialogue in Science Classrooms and Science Learning

Lemke’s (1990) seminal work describing the talk that occurs during science classes brought to light the limited opportunities students have to actively engage in discussions during lessons. Although students are typically encouraged to participate, rigid organizational structures put in place by the teacher can greatly influence the types of student responses that are deemed acceptable. In the case of triadic discourse, the
teacher will ask a question, the student will answer, and the teacher will give some type of evaluation or feedback before asking another question. Such an approach to classroom discourse is not unique to science education and has also been referred to as IRE or IRF, where the teacher initiates (I), the student responds (R), and the teacher either evaluates (E) or provides feedback (F) to the student’s response (Cazden, 1988; Mehan, 1979).

Triadic discourse has its benefits for the teacher. It allows for more student voice than lecturing in a manner that maintains control of student behavior. It is also a useful tool teachers have to quickly assess student content and procedural knowledge. Lemke (1990) suggests however, that such an approach can make learning science more difficult for many students because they are unable to decipher the overall meaning that must be extrapolated from the string of teacher questions and student responses. Furthermore, by having the teacher rigidly directing the progress of the discussions through his or her questioning and elaborations, it is the teacher that actually constructs the meaning of the lesson and engages in science talk. The limited opportunities for students to contribute ideas and combine meanings in extended responses serve to alienate some students from the science discipline and is especially problematic for those who are not exposed to the science culture outside of school (Lemke, 1990). The ubiquitous nature of this pattern (Cazden, 1988) would suggest that it may act as a cultural tool for the social practice of learning, but the limitations it imposes on student responses requires that other approaches to discourse be used in order to encourage more skillful practice of science talk by students (Polman & Pea, 2000).
Actively engaging in scientific discursive practices is not an innate skill. Its origin with Newton and Galileo at the inception of experimental science binds it to a European rhetoric that must be “unpacked” and learned (Halliday, 1999/2006). Learning to effectively communicate in this scientific genre is a difficult task for students of all backgrounds (Driver, Newton, & Osborne, 2000; Sadler, 2004). These difficulties are only compounded for students who are limited in English language proficiency (Goldenberg, 2008).

In attempting to make meaning of observable phenomena, science is not only defined by its systematic approach to investigations, but also a distinct language which utilizes generalizations, abstractions and metaphors to establish arguments (Halliday, 1998/2006). The distinctive nature of science practice and discourse can be an aspect of the discipline that renders science exclusive to select individuals. It is useful therefore to think of science in the context of Gee’s sociocognitive perspective (Gee, 2001). Because of the important role pragmatics plays in the context of science practice, this social perspective of meaning making can be considered a Discourse (with a capital D), inherently linked to an identity (Gee, 1989). As described by Gee (1989), Discourse transcends the grammatical use of language including “how to act, talk and often write, so as to take on a particular role that others will recognize” (p. 7). Proficiency in science, or any other Discourse, therefore requires practice with scaffolding from proficient members of that Discourse (Cazden, 1988). For those students who do not have parents or family ties to people involved in science-related fields, the science classroom can serve as a mode by which access to the science identity is realized, but only if authentic
chances to practice the Discourse are provided within that context. Triadic-like forms of discourse, however, provide little support for such learning to take place.

As one of many approaches towards talk in lessons, triadic discourse in and of itself is not bad. In fact, Scott, Mortimer, and Aguiar (2006) suggest that it is a necessary part of teaching science. It is the lack of balance between this rigid approach of disseminating science content knowledge and a more dialogic, meaning making focus that is essentially problematic. A study investigating middle school science students’ responses to teachers’ prompts found that students were more likely to express diverse ideas and share their thinking in writing as opposed to whole class discussion (Furtak & Ruiz-Primo, 2008). The authors attributed this difference to the students’ belief that teachers focus on assessing answers as opposed to understanding their thinking. The students’ belief that teachers are only interested in the right answer has been documented in other studies (Jiménez-Aleixandre et al., 2000; Mercer & Littleton, 2007). Attaining a “rhythm of discourse” in which science content and student ideas can mingle should be a main goal of class discussions (Scott, 1998, p.64).

Learning science and practicing science should not be considered mutually exclusive. Mercer, Dawes, Wegerif & Sams (2004) describe two aspects of guiding science talk that should be considered by teachers: the content of science and the practice of science. The content of science refers to the knowledge students acquire about phenomena, terms and procedures, while the practice of science refers to their ability to “use language to enquire, reason, and consider information to share and negotiate ideas, and to make joint understandings” (p. 362). Science teaching continues to be
predominantly authoritative and content focused (Alozie et al., 2010; Driver et al., 2000; Jiménez-Alexandre et al., 2000; Scott et al., 2006), even when the curriculum is designed to foster other approaches to talk during lessons (Alozie et al., 2010; Puntambekar et al., 2007). The ways in which teachers initiate and respond to student talk directly impacts the balance between these two components of science instruction. Diversifying the teachers’ methods to guiding talk can shift discussions towards a joint construction of knowledge in which there is a “joint commitment to a shared goal, reciprocity, mutuality, and the continual (re)negotiation of meaning” (Mercer & Littleton, 2007, p. 25).

Questioning is a key means by which teachers initiate student responses during class discussions (Bellack, Kliebard, Hyman, & Smith, 1966; Lemke, 1990; Mehan, 1979). Varying the types of questions that are asked is one way to shift classroom dialogue. Research suggests that classes where teachers encourage non-triadic discourse patterns with questions that supported divergent thinking such that multiple answers were considered and students were pushed to infer, justify, or judge resulted in more productive participation by students in discussions (Alpert, 1987; Martin & Hand, 2009; McNeill & Pimentel, 2011). Meta-analyses of studies testing the effectiveness of a more dominant usage of these types of questions showed significant gains in student achievement when compared to discourse patterns in which factual/recall questions prevailed (Redfield & Rousseau, 1981; Schroeder, Scott, Tolson, Huang, & Lee, 2007). In addition, teachers who chose to ask students to elaborate on their responses or provide feedback to other student responses, prior to teacher feedback or evaluation, stimulated
more productive student participation during class discussions (Chin, 2007, van Zee & Minstrell, 1997).

The role of the teacher in fostering various forms of discussion is therefore an essential component of science talk. The teacher will essentially establish how students will be allowed to interact during the lesson by the way they frame the discussion (Hutchinson & Hammer, 2010). A frame is a “as a set of expectations an individual has about the situation in which she finds herself that affects what she notices and how she thinks to act” (Hammer, Elby, Scherr, & Reddish, 2005, p. 9). The teacher during whole class discussions defines not only how members in the class will interact but also what type of knowledge will be accepted in the discussions (Hammer et al., 2005). Students therefore react to the cues that are given by the teacher.

Research suggests that teachers may not be aware of how they constrain dialogue to limit the amount of participation by students (Scott et al., 2006). Furthermore, the teachers may lack the skills needed to transition from the traditional IRE discourse in the classroom to one which is more dialogic, even when such an approach is called for by the curriculum, for a lesson, or activity (Alozie et al., 2010; Driver et al., 2000). Context factors and beliefs seem to play at least an equally important role in the decisions teachers make about instructional practices (Mercer, 1995; Jones & Carter, 2007). Teachers’ awareness of their science instruction as well as their beliefs must be considered and challenged in order to achieve change in the instructional strategies (Johnson, 2009).
The Problem

Science discussions in secondary classrooms continue to be dominated by teacher talk which limits the extent to which students can engage in the practice of science. Shifting this dominant pattern of interactions requires knowledge of which factors are most influencing the persistence of the current approach to talk. In this study, I hope to contribute to the developing understanding of theories about science talk in secondary science education by exploring both teachers’ and students’ beliefs about what factors influence their approach to whole-class discussions. Although some case studies exist that explore teachers’ beliefs about their approach to science talk, there are currently no large scale quantitative studies which examine teachers’ overall beliefs about their ability to engage in effective science talk, their beliefs about talk as an effective tool for learning, teachers’ beliefs about their overall approach to talk as well as the factors that influence their approach. Furthermore, limited research exists which explores students’ beliefs engaging in talk during whole-class discussions as an approach to learning. Because students are important contributors to the interactions that take place, this perspective serves to broaden the theories that currently focus only on teachers’ moves and beliefs. In this dissertation, I explore these topics by surveying secondary science teachers and students as well as investigating how a teacher and her students approach talk in a case study. The principle questions I will address are:

Main Question:

What are the factors that influence teachers’ and students’ beliefs about engaging in science talk during whole class discussions?
Sub-questions:

- What factors are associated with secondary science teachers’ efficacy and outcome beliefs about engaging students in science talk during whole-class discussions?
- How do teachers perceive their role and the students’ role in authoritative and dialogic whole-class discussions?
- What factors do teachers believe most influence the frequency and quality of science whole-class discussions during instruction?
- What is the relationship between a teacher’s perceived approach to dialogic science talk and actual instruction during whole-class discussions?
- What factors are associated with students’ beliefs about participating in science talk and the teacher’s role during whole-class discussions?

Dissertation Overview

In this chapter, I have provided a rationale for the research undertaken in this dissertation. Specifically, I provided evidence that even after various attempts at reforming the approaches taken by teachers and students towards talk in science lessons, little change has occurred in the way high school classes discuss science. I then present the questions guiding this dissertation which focus on investigating the role of both teachers’ and students’ beliefs on secondary science discourse.

In Chapter Two, I provide a review of the literature that begins with a general discussion of the sociocultural perspective as the foundational theory of this dissertation. I then describe an analytical framework specific to science education that guided my
research of approaches to science talk. I proceed by presenting a conceptual framework of teacher beliefs including the description of possible factors, both personal and contextual, that may be related to teachers’ beliefs about efficacy relating to whole-class discussions. After presenting literature describing the role of school context on teachers’ beliefs, I focus on what is known about students’ beliefs about participating in whole-class discussions. Lastly, I discuss framing as a useful conceptual lens that will be used to guide my research in terms of the expectations both teachers and students have for talk.

In Chapter Three, I present the methodology used in this dissertation that included two distinct approaches: quantitative state-wide survey of secondary science teachers and a qualitative case study of a chemistry teacher and her students. I begin with an explanation of how these two approaches work synergistically with each other to provide a more comprehensive understanding the questions understudy. Then, I proceed to describe the context, sample, and instrumentation used in the state-wide survey. In addition to elucidating the creation and refinements of the beliefs scales used in the survey, I outline the analytical methods used to investigate the possible relationships among various factors and teachers’ responses. Specific details are provided about the approach that was taken in the development of Hierarchical Linear Models (HLM), Multiple Regression Models and Chi-Square tests.

In Chapter Four, I present the descriptive statistics describing teachers’ responses to the Outcome Expectancy scale (STOES), the Efficacy Scale (STEBS), the Authoritative Approach Scale (ATAS) and the Dialogic Approach Scale (DTAS). Second, I present the significant relationships among scale scores and both school and
teacher predictors that resulted from the development of both HLM and regression models. Finally, I present chi-square statistics of teacher beliefs about the relative importance of different factors influencing the frequency and quality of science talk during whole-class discussions in which the purpose is to develop students’ understandings of a scientific concept.

In Chapter Five, I present the case study findings. First, in order to contextualize the findings, I provide descriptions of the teacher, her students, the school in which they interact and the goals of each lesson. Then, I present four themes that emerged from the analysis of the multiple data sources. The first theme focused on the interactions that occurred during the whole-class discussions and the teacher’s beliefs about her role in those discussions. The second theme showed how variations in the teachers’ approach to talk related to students’ contributions to the discussion. The third theme focuses on students’ understandings and preferences for dialogic and authoritative approaches to talk. Finally, the last theme suggests that student perspectives about the social and epistemological framing of whole-class discussions impact the dynamics that exist when students and teachers interact during lessons.

In the final chapter, I situate the major findings of this study within the broader body of science education research and practice. Subsequently, limitations of this study are presented. Finally, implications are then discussed which not only suggest topics for teacher preparation and professional development, but also address the often neglected shift at the student level that must be considered in order for science discussions in secondary classrooms to change.
CHAPTER TWO: THEORETICAL FRAMEWORK

Various frameworks will be used in this study in order to explore secondary science teachers’ and students’ beliefs about science talk during whole-class discussions. In the following section, I will begin by explaining the sociocultural perspective which underscores every element of the study. Then, I will describe the terms and theories behind the types of approaches and interactions that relate to science talk. I will proceed by setting forth a science teacher beliefs systems framework which links teachers’ beliefs to their approach toward instruction. Finally, I will conclude by discussing students’ beliefs about whole-class discussions.

Sociocultural Theory

Sociocultural theory will be used as the foundation for this study. Of particular importance is the notion that learning occurs first in the social plane with the use of cultural tools such as language before it is internalized (Vygotsky, 1978). As the content specialist, the teacher’s role is therefore to provide guided opportunities for students to exceed their present level of understanding or knowledge (Scott, 1998). The value of any activity that is done in the classroom, therefore, is mediated by the meaning that is made by the students through the interthinking that occurs during discussions associated with that activity (Mortimer & Scott, 2003). Although the teacher does hold the role of discipline master within the context of the classroom, she cannot simply transfer meaning and understandings about science onto students; the teacher’s role is to provide opportunities for students to engage in scientific practice so that they not only construct meaning of the knowledge that science has gained, but also begin the process of
enculturation into the Discourse (Gee, 1989). Scientific practice in this sense transcends simply doing an activity. Emphasis on the act of doing the activity instead of the understanding that is achieved from discussing the meaning of the practice is misplaced (Mortimer & Scott, 2003). Science learning is more than simply manipulating objects or learning facts. It includes a facility with scientific language and meanings that many times is missing from science instruction.

Lave and Wenger suggest that a significant problem with the use of language in education is the approach to teaching as knowledge transmission (1991). They say that “the conflict stems from the fact that there is a difference between talking about a practice from outside and talking from within it” (p. 107). Because science, as a domain, has evolved a technical and highly structured form of language that serves as a resource for what Halliday termed “meaning potential” (1995/2006, p.8), learning to make meaning of the abstract and generalized concepts in science is inextricably linked to being able to interact with the language that defines the field. Being educated in science is therefore being able to use language as a tool to approach phenomena with new perspectives, find new ways to interpret ideas and to problem solve (Mercer & Littleton, 2007). Such abilities come when teachers provide opportunities for students to discuss and explore their ideas as a fundamental part of learning science (Scott, 1998). Although not all students will necessarily pursue careers in science, failure to expose students to the dialogic nuances of the domain can close doors to opportunities for those who someday may want to participate more actively in science-related fields and may limit the extent to
which students can make sense of personal or political issues which involve scientific arguments.

Dialogue in Science Classrooms

The dialogue of interest in this study is specifically science talk that occurs within whole-class discussions. Using Anderson’s (2000) definition, a discussion refers to “talk among members of a group or class intended to enable ideas or information to be shared and problems to be solved” (p. 527). I am therefore interested in talk that focuses on students’ reasoning and understandings of the topics which are being discussed as opposed to repetition or statements about science content or procedures. My interest is also in the whole-class context because of its place in establishing a common understanding for the entire class of science content and practice as opposed to group or individual work where students can be constructing various meanings which may or may be in line with the discipline of science.

The analytical framework for studying the meaning making that occurs in the context of secondary science whole-class discussions set forth by Mortimer and Scott (2003) will ground my approach towards science talk in this study. According to this framework, there are five aspects of lessons which should be considered during analysis: the teaching purposes, content of the lessons, communicative approach, patterns of discourse and teacher interventions (see Figure 2.1). The teacher’s intentions for the lesson with respect to the overall objectives as well as the science content for the lesson establishes the focus of the lesson. Both of these aspects of the lesson will impact the type of approach and actions the teacher decides to take during the discussion. The
approach relates to who talks during the lesson as well as what viewpoints are accepted into the discussion. The focus and approach then play out in the actions which are observed in the class within the overall dialogue patterns and the moves that teachers make within those patterns.

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<tr>
<th>Focus</th>
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<td>Approach</td>
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<td>Is the communication interactive? Who’s doing the talking?</td>
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<td></td>
<td>How are teachers and students exchanging ideas?</td>
<td>What is the teacher doing during the discussion to support student learning?</td>
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*Figure 2.1. Mortimer and Scott Meaning Making Framework (2003, p. 25).*

**Purpose and Content of Lessons**

The purpose and content of the lesson defines the focus that the teacher will have and therefore plays an important role in the approach she takes. For example, the approach a teacher will take when the purpose of the lesson is to assess student ability to balance chemical equations is different than when the purpose is to explore student understanding of the principles which make balancing equations necessary. In the first instance, the teacher is interested in determining if the students can accomplish a specific task while in the other she is interested in the meaning that students make of the overall act of balancing. In assessing the students’ ability to perform the task, one would expect
an approach consisting of many closed questions with a focus on the correct answer. Alternatively, when the objective is to identify the students’ understandings of the principle underlying the task, more open-ended, probing questions would be used. Although it could be argued that even in the first scenario the teacher could be concerned with having the students understand the reasoning behind balancing, such a teacher would describe different objectives for the activity than the teacher who was only interested in assessing whether or not students could balance equations.

Mortimer and Scott (2003) outline six different purposes that teachers may be trying to achieve: establishing the problem, understanding student views, establishing the scientific meanings associated with the topic, supporting student thinking regarding the scientific meanings, supporting student application of the meanings, and connecting the meanings that are being made so students can grasp the interconnectedness of the ideas which are being discussed. In this study, I am most interested in how teachers approach lessons when they are trying to understand student views, supporting student thinking and their application of the meanings.

Content refers to the way in which language is being used. Mortimer and Scott (2003) propose three categorizations. In these categories, they make a distinction between talking about scientific concepts using common non-science terms and ideas versus using scientific meanings and terms during discussions. The content of the talk can also be focused on engaging in describing objects or phenomena, explaining the phenomena and generalizing about the phenomena. Lastly, these phenomena can then be discussed either empirically or theoretically. The type of contributions students make in any of the
categories is of interest in this study because as student talk moves towards the use of more scientific terms beyond description towards more theoretical discussions, it becomes closer to science talk.

*Communicative Approach*

The communicative approach refers to the overall relationship that occurs between the teacher and the students during the discussion. Mortimer and Scott (2003) present two dimensions to this aspect: interactive/non-interactive and dialogic/authoritative. Both dimensions exist on a continuum and coexist within discussions. Interactive talk occurs when more than one person is participating in the discussion while non-interactive talk excludes student participation. What most people consider as teacher lecture would be an example of a non-interactive approach to a lesson. With respect to the other dimension, if the teacher focuses solely on presenting scientific content and explanations, this is considered an authoritative approach; however, if the discussion is more geared towards developing meanings that students have and exploring their ideas, it is considered to be dialogic (Scott, 1998). A similar idea was proposed by Alexander (2000) who proposed a continuum of directed – negotiated pedagogy in which the directed pedagogy was defined by teachers who rigidly steered the discussions in the class and the negotiated pedagogy involved the embracing of various ideas during the discussion. Because the focus of this study is on learning as it pertains to meaning making and opportunities to engage in the practice of science, the authoritative – dialogic definition and terms proposed by Scott (1998) will be used.
Although the authoritative-dialogic communicative approach is defined as a continuum (Mortimer & Scott, 2003), there are features associated with each extreme which help to characterize them. The main features of each approach are described by Scott et al., 2006. Authoritative approaches to talk are associated with teacher-dominated contributions which rigidly steer discussions within clear content boundaries. Dialogic approaches are characterized by greater co-participation between teacher and students in the ideas that are presented during the discussions. Where the teacher places herself on this authoritative-dialogic continuum greatly influences the other two aspects of analysis: the patterns of discourse and teacher interventions.

*Patterns of discourse*

The patterns of discourse or interactions that occur during a lesson are defined by exchanges that occur between teachers and students. As previously described, the predominant pattern associated with science lessons tends to be triadic in which the teacher asks a question, the student answers and the teacher provides some type of evaluation or feedback (Lemke, 1990). This pattern however is associated with authoritative approaches to talk. During dialogic discussions, triadic interactions are much less likely and new patterns which include direct student exchanges and student questioning emerge.

These patterns are directly linked to the approach teachers take to questioning. Questioning is a key means by which teachers initiate student responses during class discussions (Bellack et al., 1966; Lemke, 1990; Mehan, 1979). Many frameworks exist which categorize questions, one of the most recognized systems for coding questions
being Blosser’s Question Category System for Science (1973). For this study, Blosser’s
distinction between “closed” and “open” questions is important. Questions are
considered to be “closed” if teachers expect a limited response to focus thinking towards
a set of right answers while “open” questions allow for more than one interpretation or
response such that thinking is not restricted to one expected answer, thereby asking
students to justify, infer, design or judge (Blosser, 1973). These two categories
correspond well with the two components of science instruction where closed questions
would be associated with a focus on content knowledge and open questions would be
associated with the practice of science such as asking for students to actively engage with
information and provide reasoning.

Carlsen (1991) however cautions that the meaning or intentions of questions “is
dependent on their context in discourse” (p. 157). Closed and open questions may
actually be phrased in the same way, but it is the teacher’s response to the student’s
answer that illuminates the purpose of the initial question. Therefore, in conventional
triadic organizational patterns (Lemke, 1990), the teacher’s reactions to the student
responses formally frames the intention of the questions and the expectations that all
discussion participants have for the type of dialogue that will be accepted in that lesson
(Carlsen, 1991). For example, a teacher may ask “What do you think?” In one case, this
type of question would invite students to contribute their understanding of particular
concept under discussion. However, it can also be seen as an alternative to asking “What
is your answer?” Depending on how the student responds and the teacher reacts, one can
then determine the type of the question it was. If the student explains his thinking and it
is accepted then the question was open, but if the student gives a direct answer and the
teacher evaluates it without further probing, it was closed. The dialogic moves that
teachers make before and after student responses are therefore of great significance
during science talk, thereby leading to the last aspect of interest which is teacher
interventions.

Teacher Interventions

Teacher interventions as defined by Mortimer and Scott (2003) focus on the
teacher moves which help define science understandings. Because the six proposed
interventions include moves for various foci beyond those of interest with respect to
dialogic talk, only sharing ideas and checking student understanding will be considered.
Sharing ideas focuses on actions that teachers take that encourage students to
communicate their thinking to the entire class. Some examples are asking students to
share, having students repeat their ideas so the whole class can hear them, or asking
students to present their findings to the class. Checking student understanding focuses on
having teacher probe students for the meaning they are making of the topic under
discussion. In this case, the action taken by the teacher would be asking students to
elaborate on their responses and checking with the class for overall ideas. In all cases, it
seems that questioning plays an important role in the action that teachers take as they
shift from evaluative actions to those which encourage student talk.

Chin’s (2007) categorization of effective questioning techniques is therefore an
appropriate model to use for analyzing teacher interventions. For the purpose of this
study, I will focus on the questioning strategies she proposed as feedback which were
used to effectively guide student thinking for the collaborative construction of knowledge: pumping, reflective toss, and constructive challenge. In each case, elaboration on student answers is solicited by teachers prior to any evaluation. While pumping simply encourages students to elaborate on their own prior answer, the constructive challenge asks students to reconsider their response given new information. The reflective toss, which was first suggested by van Zee and Minstrell (1997), places the responsibility on students to remark on elements of the discussion prior to teacher commentary. These categories not only link directly with the Mortimer and Scott (2003) framework, but also dovetail well with the talk strategies that Mercer and Littleton (2007) propose in their description of how teachers can support more dialogic student discussions: “asking why, checking that a range of views are heard and giving examples of reasons for opinions” (p. 74).

In researching the extent to which math teachers modeled dialogic talk, Mercer and Sams (2006) looked at the extent to which several elements appeared in the teacher talk: 1) asking students to explain their reasoning with “why” questions, using reasoning words, giving reasoning for their statements, checking that all ideas had been voiced and seeking agreement from the class in debates. Such an approach incorporates Blosser’s (1973) and Chin’s (2007) questioning strategies but it goes further than the simple questioning framework approach because it incorporates the many ways in which teachers model the type of talk associated with dialogic teaching. Looking at teacher talk within discussions using both the questioning framework and the Mercer and Sams
(2006) approach will enhance the description of the teacher’s role within the approach and the evidence patterns in whole-class discussions.

**Student Responses**

Student responses are only peripheral pieces of the Mortimer and Scott (2003) framework. While student responses are considered in the framework in order to establish the content, communicative approach, and interactive patterns, this framework does not provide a way to analyze the extent to which students’ responses are authoritative or dialogic. Student contributions in dialogic class discussions are different from those that routinely appear in triadic dialogue, however. Considering the manner in which students are contributing to the discussions more is equally important in establishing the type of science talk that is taking place. Within true discussions students ask questions of the teacher, refer to ideas that have been previously presented in the discussion, and suggest possible new ideas to the discussion (Lemke, 1990). Mercer and Littleton (2007) referred to this type of talk as “exploratory” in their research on group talk. They suggest that dialogic student responses were typically longer than those that are found in triadic discourse and are associated with reasoning indicator words. Like Mercer and Sams (2006), Mercer and Littleton (2007) were interested in the extent to which the reasoning indicator words appeared in the dialogue. The indicator words they focused on were “because/cuz”, “I think”, “if”, “why”, “which”, “what”, “you – when used in a question”, “agree” and “so” (p. 101). They found that in discussions that could be considered more dialogic, these words appeared more frequently. The words however were only counted if they were associated with reasoning. Such an approach is useful
and will be used as another measure of the extent to which dialogic discussions are occurring in class.

Teachers’ Beliefs

Teachers’ beliefs have been characterized as being both stable (Pajares, 1992) and context-dependent (Bandura, 1986; Mansour, 2009). The complex nature of beliefs makes them hard to quantify (Pajares, 1992). Considering them in relation to teachers’ approaches towards discussions is important, however, because teachers’ beliefs seem to play a significant role in how they frame instructional activities (Nespor, 1987, Pajares, 1992; Torff & Warburton, 2005). Louca, Elby, Hammer, and Kagey (2004) suggest that because beliefs are so dependent on context, science teachers’ approaches to instruction may differ significantly from those they vocalize. Similar inconsistencies were apparent in another study by Simmons et al., 1999, suggesting that the relationship between beliefs and practices is complex. Adding to this complexity is the suggestion that teachers may not be aware that their stated beliefs are inconsistent with their actual instruction (Tobin & McRobbie, 1997).

In this study, I am concerned with teachers’ beliefs about the type of instruction they engage in, as well as the factors that influence their approach. I draw on work from Chinn and Samarapungavan (2009), defining a belief as a conceptual structure that is perceived to be true or correct. In this study, I focus on these perceptions relative to teachers’ beliefs about themselves, their students, and other external factors that they suggest may be influencing their approach to class discussions. While beliefs may be stable, they act within a beliefs system that includes other beliefs about contextual
factors. It is true that discrepancies in teachers’ beliefs about instructional practices and their use of these practices may exist at times, but Munby’s (1982) notion that “different and weightier” (p. 216) beliefs may be an explanation for this phenomenon. Cross (2009) took on a similar approach, following a framework of belief systems, suggesting that math teachers’ beliefs about instruction existed on more than one dimension. He suggested that while teachers may hold “core” beliefs in one dimension, they are independent from the “peripheral” beliefs that are more context-dependent (p. 327). These beliefs are separate and may be inconsistent with each other. They work together within a system to explain the behaviors that teachers practice. In his study, Cross found that teachers’ beliefs were actually good predictors of the teachers’ instructional practices.

While I am interested in teachers’ core beliefs about student-centered discussion and its role in science instruction, I am also interested in teachers’ beliefs about the context in which they are teaching in order to better understand the role of beliefs in explaining the approach teachers take to discussions. The approach teachers choose to take is a result of the interplay among beliefs, experiences and context (Jones & Carter, 2007; Roehler, Duffy, Herrman, Conley, & Johnson, 1988). Given that science teachers’ beliefs have been demonstrated to play a role in how teachers implement curriculum, Cronin-Jones (1991) showed that it is important to consider teachers’ enactments of reform-based curricula as being filtered through the beliefs teachers have about their instructional role, their students abilities, and the importance of the topic being taught.
Pajares (1992) suggests that beliefs are not likely to change “unless they are challenged and one is unable to assimilate them into existing conceptions” (p. 321). In order to challenge teachers’ beliefs about student-centered and dialogic science talk, it is important to know what those beliefs are and consider how we can better help teachers question their present perceptions.

Because the teachers’ main goal during instruction is student learning, it is hypothesized that the extent to which teachers use dialogic talk in their classroom as an instructional tool is influenced by the efficacy they associate with that tool. In researching science teachers’ beliefs about their teaching, Riggs and Enochs (1990) found that two separate constructs exist which must be defined when measuring efficacy beliefs: self-efficacy and outcome expectancy. In this study, self-efficacy is being defined as “the teacher’s belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context” (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998, p. 22). Therefore, self-efficacy in this study refers to the belief a teacher has about his or her ability to effectively engage students in whole-class science talk. The outcome expectancy beliefs refer to the teacher’s beliefs that effective teaching using whole-class discussions can bring about student learning (Riggs & Enochs, 1990). Because each construct may influence teachers’ approaches to whole-class discussions, both self-efficacy and outcome expectancy will be investigated in this study.

In the sociocultural model of embedded belief systems (Jones & Carter, 2007), efficacy is one of many elements that interact synergistically. To understand the
underlying system by which teachers operate when they choose to engage students in various forms of science talk, several key aspects of the model must be considered. The model consists of seven basic categories: Efficacy, Social Norms, Environmental Constraints, Epistemologies, Attitudes towards Instruction, Attitudes towards Implementation, Knowledge, Skills and Motivation. Teacher beliefs in these categories then interact, move through a perceptual filter, get affected by environmental responses and then lead to the type of instructional practice that is enacted.

As a theoretical model of beliefs, this model is thought-provoking and attempts to show the complex relationship among all of the factors that impact teacher decision making. Jones & Carter (2007) suggest that the instructional practice decisions that teachers make “are influenced by the relative weights of the components of the belief system” (p. 1076). It is these relative weights or correlations that I am interested in investigating. My focus is on how the various beliefs and factors in the system are related to efficacy as well as instruction.

This study will therefore use an adaptation of this framework which situates teacher beliefs about their efficacy to incorporate science talk during instruction between the beliefs they have relative to themselves, which I have called the Personal Factors and those they have about other influences they perceive outside of themselves, which I have called the Context Factors (see Figure 2.2). This approach follows Maxion’s categorization of beliefs into external and internal factors (as cited in Mansour, 2009). It is the interplay among the personal factors as well as outside influences that determines a teacher’s determination of her efficacy to use science talk during instruction. Unlike the
original Jones and Carter model (2007), I have made a clear distinction between personal and outside factors. Although they interact to impact efficacy and overall instruction, personal factors in this model are independent of context factors and are associated with the teachers’ background.

![Figure 2.2. Adapted beliefs framework based on sociocultural model of embedded beliefs systems (Jones & Carter, 2007).]

There are three personal factors of interest in this study: experience with guiding talk, confidence with content knowledge, and pedagogical knowledge of strategies to
guide talk. Studies suggest that some teachers lack skills and pedagogical knowledge of strategies that can facilitate science talk (Driver et al., 2000; Jiménez-Aleixandre et al., 2000). Also, when teachers lack certain knowledge and skills, they are less likely to enact an instructional practice (Sequeira, Leite, & Duarte, 1993). Teachers’ own school experiences and positive experiences in the classroom with instructional practices will also influence their approach to talk (Mansour, 2009). Teachers tend to teach in the way they were taught (Lortie, 1975; Tobin, Tippins, & Gallard, 1994). These factors are therefore important to consider when investigating teacher beliefs towards dialogic talk.

There are also many context factors to consider. Jones and Carter (2007) refer to them as social norms and environmental constraints. I have categorized them according to their source: non-student and student. Non-student sources are associated with expectations of those who are not directly in the classroom during instruction, the curriculum and organizational issues. The sources of interest in this study are administrative, colleague and parent expectations, curriculum focus, time and class size. Such outside sources have been cited as common external factors with time pressures being the main reason for a fact-oriented approach to instruction (Mansour, 2009). However, new pressures being placed on schools to perform well on achievement tests have also greatly influenced the type of instruction that takes place in the classroom as well as the expectations placed on teachers to focus more on content delivery, especially in urban settings (Crocco & Costigan, 2007). Teacher beliefs about “curricular and institutional constraints” were shown to impact the adoption of alternative more dialogic methods during math instruction (Cross, 2009). Understanding teacher perceptions about
these external factors are important even though they influence the context of the class indirectly, because they impact teacher decision making as to the type of approach they take during instruction.

Student factors refer to those characteristics students bring with them to the class that may influence the type of interactions that can occur between them and the teacher: content knowledge, experience, motivation, academic ability, English Language Proficiency, expectations and behavior. The feedback that teachers receive while interacting with their students impacts the beliefs they have about what types of instructional strategies work and which do not (Mansour, 2009). Depending on how teachers view talk as a learning tool, their responses to the influence of certain factors, like student academic ability and content knowledge, will be different. If the teacher views talk as a means of assessing content knowledge, then these factors will be very important in the perceived quality of talk that can take place. However, if the teacher views talk as a means of getting at student understandings and ideas, previous content knowledge or academic ability should be less important. Students are also rarely taught by teachers how to actively engage in dialogic talk (Mercer & Littleton, 2007), therefore lack of student experience with talk may be a reason given for why teachers shy away from dialogic talk. As has been previously cited, authoritative talk is also a means by which teachers can control interactions (Lemke, 1990). Behavioral issues with students therefore may be a significant factor in determining the beliefs teachers have about talk.

Teachers’ beliefs about whole-class discussions are context dependent and therefore the influence of beliefs on the teachers’ approach depends on the specific
context they place themselves in (Mansour, 1990). In the case of secondary science teachers, this adds an additional challenge. Many teach several classes a day, of different sizes, which may be in different disciplines and, depending on the school, could have classes leveled by perceived student academic ability. It is therefore important to have teachers define the context within which they are accessing their beliefs systems. Many researchers have suggested that teachers’ beliefs about instruction are many times inconsistent with what their actual instruction, such inconsistencies however can be explained by the fact that different belief elements dominate within different contexts (Jones & Carter, 2007).

Examining teacher beliefs about science talk in a big scale is important because it will help to identify which major factors are related to teacher beliefs about talk. This understanding is fundamental if we hope to shift the focus of discussions from being predominantly fact-oriented to focusing on ideas and understandings.

School Context

Recent pressure to perform well on state achievement tests in order to show school progress has had an impact on teachers’ approaches to instruction especially in urban areas (Nichols & Berliner, 2007). The focus on transmitting the required knowledge, sometimes by way of scripted lessons, is especially felt in urban districts that serve the highest percentage of socioeconomically disadvantaged students due to their continuous failure to meet adequate yearly progress (Crocco & Costigan, 2007). Studies also suggest that teachers of poor or working class students tend to focus more on facts and basic skill acquisition, while those teachers in affluent communities stress knowledge
as discovery, creativity and thinking (Anyon, 1981). Such a trend is important to investigate with regards to authoritative versus dialogic talk because of the previously mentioned role that dialogic talk plays in allowing students to actively practice scientific discourse. Consequently, I have chosen to include a school average socioeconomic predictor within my research in order to identify if differences in teachers’ beliefs about science talk and the factors that influence teachers’ approaches to talk vary as a result of the schools’ overall status.

Students’ Beliefs

Dialogic interactions during science talk requires the co-participation of students with the teacher, however limited research exists on how students approach discussions during class.

While studying the discourse patterns in high school English classes Alpert (1987, 1991) found that students were more likely to resist teacher solicitations for them to participate in discussions as opposed to other activities such as reading and homework. He also concluded that when teachers used more dialogic forms of talk in which they were responsive to student knowledge and ideas that students were less likely to resist talk. Similar resistance has been described in science classes with students being less motivated to discuss their ideas in class because of their belief that the teacher is looking for the “right answer” (Furtak & Ruiz-Primo, 2008). Research suggests that teachers may not be aware of how they constrain dialogue to limit the amount of participation by students (Scott et al., 2006), but most of the literature focuses on how researchers view the dialogue as opposed to the students’ beliefs about how dialogue is being encouraged
or discouraged and their place in the discussion. Dialogic talk requires students to actively engage in the discussions and therefore investigating what factors influence student participation in class is equally important.

The main focus of my study on student beliefs will focus on how they are framing the talk that occurs in the class. By framing, I mean “the set of expectations an individual has about the situation in which she finds herself that affects what she notices and how she thinks to act” (Hammer et al., 2005, p. 98). Framing can occur at many levels, but for this study I will focus on the social and epistemological beliefs students have towards science talk. The social level is defined by the types of interactions that the students expect to have while talking during discussions. The epistemological level defines what type of knowledge they believe is accepted in the discussion (Hammer et al, 2005). In a typical IRE pattern in which a teacher is trying to assess content knowledge, the implied frame for social interactions is that interactions flow to and from the teacher and the epistemological level focuses on the scientific cannon of knowledge. By exploring students’ framing of whole-class discussion, I can better understand how students’ expectations of talk may also influence the persistence of authoritative approaches to talk in many secondary science classes.

It is evident that as a social means of learning, the types of whole-class discussions that occur in secondary science classes result from the framing and beliefs held by both the teacher and his or her students. While substantial research exists about teachers’ beliefs in general, there are presently no large-scale quantitative studies investigating teachers’ beliefs specifically towards different approaches to science talk.
during whole-class discussions and the factors that are most related to these beliefs. Furthermore, minimal research exists which elucidates the students’ beliefs and role in the discussions. Consequently, in this study I investigate teachers’ and students’ beliefs about engaging in science talk during whole class discussions.
CHAPTER 3: METHODOLOGY

This dissertation utilized both quantitative and qualitative methods to investigate teachers’ and students’ beliefs about approaches to whole-class discussions. In order to investigate possible correlations between teachers’ efficacy beliefs about dialogic science talk and various factors that may be related to those beliefs, a statewide survey was conducted of Rhode Island secondary science teachers. The statewide survey was used to measure the extent to which teachers believe dialogic talk is an effective approach for learning science as well as explore which factors teachers believe most inhibits their ability to engage in this type of talk. Furthermore, I was able to determine if there was a significant difference in these beliefs among teachers of schools of varying socioeconomic conditions. A case study approach was used to explore a teacher’s and her students’ beliefs about their roles within science talk because of its instrumental value in better understanding the interplay between teacher beliefs about talk and the context in which talk actually occurs (Stake, 2000). This second context allowed me to better explore how different factors influencing talk are understood by the teacher as well as her awareness of the approaches she used. By collecting data from students, I was also be able to compare the teacher’s understanding of her approach to talk with the students’ perceptions about talking during science lessons. Because science discussions involve a dynamic interplay between the teacher and her students, exploring the beliefs students bring to discussions is also important. Together these two different approaches serve to elucidate general beliefs teachers have about talk and factors that most influence the quality of that talk at two different levels: as understood by the collective teacher
population of a state and as understood by a teacher within the specific context of her classes. Both levels provide different but complementary data which together were used to depict a more comprehensive understanding of how teachers and students approach talk during whole-class discussions. In this section, I describe each of the two methods in detail including the participants, data sources and data analysis techniques.

Methods – Statewide Survey of Secondary Science Teachers

Survey Development

The survey instrument consisted of five parts: (1) context questions, (2) the Science Talk Efficacy Beliefs and Outcome Scales, (3) the Science Talk Approach Scale, (4) the Factors Influencing Talk Likert Scales, (5) and the background information section (Appendix A). Each section provided measures for predictors that were tested in the study.

Context questions. Because research suggests that teachers’ beliefs are influenced by context (Jones & Carter, 2007), teachers were asked to answer the questions on the survey in relation to a specific science class. After stating an estimation of the percentage of instructional time devoted to whole-class discussions, teachers were asked to rate their perceptions relative to student factors such as motivation and academic ability as well as personal factors such as content knowledge relative to the class they were using as a source of answers to the questions. Teachers rated these perceptions on a scale from 0 – 10, where 0 was significantly below average or problematic and 10 was significantly above average or superior (Appendix A1).
Science Talk Efficacy Beliefs and Outcome Scales. The first beliefs scale measured teachers’ efficacy and outcome expectancy beliefs relative to the use of science talk during whole-class discussions. The items of the Science Teaching Efficacy Beliefs Instrument (STEBI) (Riggs & Enochs, 1990), a scale used to measure elementary teachers’ beliefs about teaching science in general, was adapted to create a scale that measured secondary science teachers’ beliefs about science talk. Similar to the original STEBI, the beliefs scale in this study was composed of two subscales: the Science Talk Efficacy Beliefs scale (STEBS) and the Science Talk Outcome Expectancy scale (STOES).

Language characterizing dialogic science discourse (Scott et al., 2006) was incorporated into the self-efficacy scale to measure the teachers’ beliefs about their ability to guide students in dialogic talk during whole-class discussions (Appendix A2). For example, for the item “Even when I try very hard, I don’t teach science as well as I do most subjects,” the wording was changed to include dialogic talk characteristics such that the new item read, “Even when I try very hard, I don’t teach as well when class discussions diverge from the specific content I planned to talk about.”

The outcome expectancy scale measured teachers’ beliefs about the effectiveness of talk for student learning (Appendix A3). It was modified in a similar way as the self-efficacy beliefs scale. For example, for the item “When a student does better than usual in science, it is often because the teacher exerted a little more effort,” the wording focused on the teachers’ beliefs about the impact of dialogic talk features and became, “When a
student does better than usual in science, it is often because the teacher made an extra effort to talk to that student about their ideas and understandings.”

Unlike the original scale, teachers were asked to respond to the items using an eleven-category scale ranging from 0-10: 0 reflecting their total disagreement with the statement and 10 their total agreement with the statement. Bandura (2006) suggests that because respondents rarely choose the extreme options on Likert scales, using scales with more gradations allows for greater sensitivity and reliability than 5-point scales. For positively worded items, scores were retained according to the teachers’ responses. Negatively worded items were scored in the reverse order with 0 being given the value of 10 and so forth. After the administration of the survey, scale scores were determined by calculating the average score for items in the scale (DeVellis, 2003). Prior to calculating the teachers’ scale scores, confirmatory factor analysis was used to explore factor loadings and the reliability of the scales were tested. These analyses will be described later in this section.

Science Talk Approach Scale. Items describing authoritative and dialogic discourse as outlined in Scott et al. (2006) were used to create a scale measuring teacher attitudes towards these different approaches towards talk (Appendix A4). Teachers were asked to express the extent to which they believed each feature was important for effective science talk during whole class discussions. A four-category Likert scale was used to capture teacher responses. Each category was assigned a score ranging from 0-3: Extremely Important = 3, Very Important = 2, Somewhat Important = 1, and Not At All Important = 0. After the administration of the survey, scale scores were determined by
calculating the average score for items in the scale (DeVellis, 2003). Prior to calculating
the teachers’ scale scores, confirmatory factor analysis was used to explore factor
loadings and the reliability of the scale was tested. These analyses will be described later
in this section.

DeVellis (2003) states that because no well-defined set of universal items exist to
capture beliefs, it is difficult to fully ascertain the content validity of these scales. He
therefore suggests that “the researcher might ask colleagues familiar with the context of
the research to review an initial list of the items and suggest content areas that have been
omitted that should be included” (p. 50). After creating the scale items in accordance
with previous research on beliefs and science talk, I asked Dr. Katherine McNeill to
review the items to increase the content validity of the scales. Because of limited
quantitative research related to teachers’ beliefs about approaches to science talk during
whole-class discussions, it was not possible to check the construct validity of these scales
with other measures of beliefs related to whole-class discussions. While these scales
serve to explore initial beliefs teachers have about approaches to talk, they are not meant
to predict their actual instruction.

Factors Influencing Talk Likert Scales. Items measuring teachers’ beliefs about
factors that influence the frequency of effective science talk as well as the quality of talk
that can occur were constructed using the Sociocultural Model of Embedded Beliefs
Systems (Jones & Carter, 2007) (Appendix A5). The items in this part of the
questionnaire measured teachers’ beliefs about the influence of four general groups of
factors on the science talk: (a) context constraints – expectations of others, (b) context
constraints – school factors, (c) context constraints – student factors, and (d) personal constraints. As mentioned earlier, context constraints – expectations of others refer to outside sources such as administrative or parent expectations. School factor constraints refer to curriculum or class size. Context constraints associated with students are those factors that teachers perceive to exist which are directly associated with the students such as ability, motivation and experience. Personal constraints are those limiting factors pertaining to the teacher him- or herself such as content knowledge or skills. A Likert scale with four categories was used to capture teacher responses. Each item was given a score ranging from 0-3 depending on each teacher’s response: Extremely Important = 3, Very Important = 2, Somewhat Important = 1, and Not At All Important = 0.

Teachers’ Background Information Section. Background information items were included in order to explore relationships between these personal predictors and teachers’ beliefs as determined by their beliefs scale scores (Appendix A6). Items in this section included questions relating to years of teaching experience, degrees attained, certification status, and professional experiences focusing on talk. Teachers were also asked to provide the name and location of their school in order to test school-level predictors in the statistical analyses that will be described later in this section.

Pretesting of the electronic survey took place with two science teachers from a nearby state following the systematic approach suggested by Fowler (2009). Clarity of instructions, questions and answer expectations were discussed. Feedback was also solicited from pretest teachers about the overall format of the electronic survey (Dillman et al., 2009). Items and formatting were adjusted as a result of the comments attained.
Survey Administration

The entire population of secondary, public, non-charter, science teachers in the state of Rhode Island were asked to participate in the survey. Random sampling was not used due to the relatively small number of science teachers (N=402) employed in the 44 comprehensive, public state high schools. The census approach also allowed for a more accurate determination of non-response bias associated with missing data, an issue that greatly impacts the overall representativeness of the sample (Kano, Franke, Afifi, & Bourke, 2008). Although there are trade offs between sampling error and non-response error that can occur when entire populations are surveyed (Dillman, Smyth & Christian, 2009), this approach allowed for non-respondents to be accurately defined and for the limitations of the study to be more apparent.

Survey data was collected initially using internet tools given that response quality has been observed to be better using this mode of administration (Truell, 2003). In the state of Rhode Island, all teachers have access to email through their respective schools. An initial list of teachers was obtained from the Rhode Island Department of Education Website. Teacher email addresses were then obtained from each high school website. An invitation to participate in the survey was emailed to all teachers which included a link to the electronic survey instrument on SurveyMonkey™. After 4-7 days of the initial survey distribution, a reminder notice was sent via email to non-respondents in order to increase response rates (Truell, 2003). After 7 more days passed, another reminder notice was sent. Alternative response options were given such as the distribution of paper surveys that were returned by mail for those teachers who failed to respond to the second
reminder (Zhang, 1999). As an incentive to participate, teachers who completed the survey were given the opportunity to enter a raffle to win an Apple iPad. The winning teacher was notified via email and the iPad was delivered to her school.

**General Data Preparation**

Data preparation prior to analyses consisted of deleting the responses of teachers who did not provide answers on any beliefs scales, addressing missing data in the beliefs scales, dummy coding categorical predictors that would later be used in statistical models, and incorporating school level data.

While 213 teachers began the survey, 32 respondents did not continue past the first page. The answers of these respondents were deleted from the data leaving 181 participants in the survey study. It was found that fourteen of these remaining respondents failed to respond to only one item on one of the four beliefs scales. A missing response by the respondents to one item occurred equally in all of the scales and was not associated with any one specific item. For example, three respondents failed to respond to one item on the DTAS scale, however these items were all different from each other. Because the missing data appeared to be random and non-systematic, the missing item response was replaced with the average respondent score on that scale (Fowler, 2009; Rässler, Rubin, & Schenker, 2008). Comparison of the mean and standard deviation of scale scores for each scale before and after the replacement of missing data using a t-test analysis showed a statistically insignificant percent change in mean score and standard deviations with the science talk approach scale mean score and standard deviations remaining constant.
Dummy coding of categorical data was performed on the teacher degree attainment predictors. Background information regarding degree attainment was coded such that numerical values were given to each response. In the case of undergraduate degree major, biology was chosen arbitrarily as the reference group because there is no theoretical basis to suggest any specific degree is a better choice for a target group. The graduate degree category was made dichotomous such that teachers were categorized as either attaining or not attaining a graduate degree. Lastly, because the distribution of teachers’ responses to workshop participation was positively skewed such that 40% stated they had never participated in a course/workshop which focused on guiding science talk, this variable was also made dichotomous such that teachers reporting course/workshop participation were compared to those who reported participation in at least one course/workshop.

School data was obtained from the Rhode Island Department of Education website. For each school, the percentage of White students, the percentage of students not participating in the Free/Reduced Lunch (FRL), and the average school average score for 11th graders in science on the New England Common Assessment Program (NECAP) were obtained. These data were then introduced as new predictors which supplemented the teachers’ responses. Because the distributions of school percentages relating to White student demographics and FRL participation were both negatively skewed, the arcsine transformation was used to establish a more normal distribution of the data (Keppel & Wickens, 2004).
Analyses of Scales

Principal component factor analysis of the beliefs scales were performed to determine the number of latent predictors associated with the items of the scales (DeVellis, 2003). For all scales, factor loadings were analyzed, different components were considered and categorized, and items were removed from the scale when appropriate in order to establish a group of items for each scale. A list of items included in each scale as well as the reliability estimates are summarized in Table 3.1.

Table 3.1. Teacher Science Talk Beliefs Scales

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>Cronbach’s alpha</th>
<th>Survey Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Talk Outcome</td>
<td>0.79</td>
<td>6 Items</td>
</tr>
<tr>
<td>Expectancy Scale</td>
<td></td>
<td>- When a student does better than usual in science, it is often because the teacher made an extra effort to talk to that student about their ideas and understandings during whole-class discussions.</td>
</tr>
<tr>
<td>(STOES)</td>
<td></td>
<td>- When student learning improves, it is most often due to their teacher having found more effective approaches towards talking with them about science during whole-class discussions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The inadequacy of students’ science backgrounds can be overcome by effective teaching approaches that encourage students to talk about their understandings during whole-class discussions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- When a low achieving child progresses in science, it is usually due to extra attention given by the teacher during class discussions to help the student reflect on his/her thinking.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- If parents comment that their child is showing more interest in science at school, it is due in part to the teacher’s approach to talk during whole-class discussions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Effectiveness increasing student participation in talk during whole-class discussions has little influence on the achievement of students with low motivation.</td>
</tr>
</tbody>
</table>
Science Talk
Efficacy Beliefs Scale (STEBS)

<table>
<thead>
<tr>
<th>Item</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.78</td>
<td>9 Items</td>
</tr>
<tr>
<td>- I am continually finding better ways to engage my students in talking about different perspectives in science during whole-class discussions.</td>
<td></td>
</tr>
<tr>
<td>- I know the steps necessary to effectively help my students to build on and apply new ideas through talking with others during whole-class discussions.</td>
<td></td>
</tr>
<tr>
<td>- I understand science concepts well enough to be effective in encouraging students to contribute their ideas during whole-class discussions.</td>
<td></td>
</tr>
<tr>
<td>- I find it difficult to allow whole-class discussions in science to veer away from my intended lesson plan when students initiate new ideas about the content we’re studying.</td>
<td></td>
</tr>
<tr>
<td>- I am typically successful at having students elaborate on their reasoning during whole-class discussions.</td>
<td></td>
</tr>
<tr>
<td>- I wonder if I have the necessary skills to orchestrate effective student science talk during whole-class discussions.</td>
<td></td>
</tr>
<tr>
<td>- Given a choice, I would not invite the principal to evaluate me when the class is focused on learning science through whole-class discussions.</td>
<td></td>
</tr>
<tr>
<td>- When teaching science, I am good at getting students to talk more to each other during whole-class discussions than directly to me.</td>
<td></td>
</tr>
<tr>
<td>- I don’t know what to do to get my students to take a more active role in science talk during whole-class discussions.</td>
<td></td>
</tr>
</tbody>
</table>

Dialogic Talk Approach Scale (DTAS)

<table>
<thead>
<tr>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.78</td>
</tr>
<tr>
<td>- Teacher asks students to clarify or elaborate on their responses.</td>
</tr>
<tr>
<td>- Teacher and students build on each other’s ideas.</td>
</tr>
<tr>
<td>- Students contribute personal points of view.</td>
</tr>
<tr>
<td>- Teacher is open to different points of view.</td>
</tr>
<tr>
<td>- Students initiate new ideas into the discussion.</td>
</tr>
<tr>
<td>- Students provide reasoning when they contribute to discussions.</td>
</tr>
<tr>
<td>- Students talk directly to each other.</td>
</tr>
<tr>
<td>Authoritative Talk Approach Scale (ATAS)</td>
</tr>
<tr>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>6 Items</td>
</tr>
<tr>
<td>- Teacher evaluates and provides feedback immediately after student contributions.</td>
</tr>
<tr>
<td>- Teacher focuses only on the scientific explanation for phenomena.</td>
</tr>
<tr>
<td>- Teacher rigidly guides the direction of the discussion.</td>
</tr>
<tr>
<td>- Teacher reshapes and elaborates on student responses.</td>
</tr>
<tr>
<td>- Teacher questions students about content facts and vocabulary.</td>
</tr>
<tr>
<td>- Students contribute to the discussion only when called upon by a teacher.</td>
</tr>
</tbody>
</table>

Factor loadings for the final six items in the STOES produced one component with an Eigenvalue greater than one. This component accounted for 49% of the variance in scores. Five items were removed from the original scale. In the initial factor analysis one item clearly did not load with the other items. This item included the adjectively “rigidly” which is thought to have skewed teachers responses in this particular case. Furthermore, several reverse items loaded as a separate component with an eigenvalue of 1.32. Because teachers may have approached these negatively worded responses in a different way, they were excluded from the scale. The reliability estimate associated with the final STOES was 0.79.

The final STEBS scale focusing on teachers’ self-efficacy included nine items that loaded to create on one factor with an Eigenvalue of 3.51 which accounted for 39% of the variance in the teachers’ responses. Four items were removed from the initial scale because they loaded more strongly in different components with eigenvalues less than one. Their inclusion in the scale also resulted in a decreased reliability of the scale (Cronbach’s alpha = 0.76). Similar to the STOES scale results, the items that were
removed where reverse-coded items. Teachers may have approached these negatively worded items differently. Including only the 9-items comprising the component with the eigenvalue greater than one, the reliability estimate associated with STEBS was 0.78.

Factor loadings for the teacher responses to the Science Talk Approach scales followed the theorized separation of the items into the Dialogic Talk Approach Scale (DTAS) and the Authoritative Talk Approach Scale (ATAS) overall. The dialogic scale comprised seven items and produced only one final loading with an Eigenvalue greater than one. The Eigenvalue associated with this component, 3.09, accounted for 44% of the variance in teacher responses. The reliability estimate for the responses DTAS as measured by Cronbach’s alpha was 0.78 suggesting that it was an acceptable-to-good scale. All seven items were therefore retained in this scale. The authoritative scale, composed of the remaining six items, also produced only one component with an Eigenvalue greater than one. The Eigenvalue associated with ATAS, 2.22, accounted for 37% of the variance in teacher responses to the items on the scale. The reliability estimate for the responses to ATAS as measured by Cronbach’s alpha was 0.65 which was lower than the other three scales used in this study. This estimate falls within the questionable to acceptable range according to George and Mallery (2003) and therefore conclusions relative to this scale will be considered with caution.

Hierarchical Linear Models

Two-level hierarchical linear models were used to investigate the possible relationships between teachers’ beliefs scale scores and other predictors (Raudenbush & Bryk, 2001). This analysis took into account that teachers were nested in schools and
school-level factors may influence their beliefs. The main question associated with this analysis was *What factors are associated with secondary science teacher efficacy and outcome beliefs about engaging students in science talk during whole-class discussions?*

Before beginning the analysis, further preparation of the SPSS files was required. While there was teacher representation from 43 schools in the state for the survey, only 30 schools and 160 teachers were included in this analysis because schools with fewer than three teacher respondents were excluded from the analysis in order to have sufficient variation at Level-1 (i.e., teacher level) (Raudenbush & Byrk, 2001). This requirement caused many small urban schools to be excluded from this analysis.

First, a fully unconditional model was created to compute the intraclass coefficient (ICC) associated with each scale. Because the results associated with only one scale (STOES) showed a statistically significant variation in scores between schools (i.e., a clustering effect), hierarchical linear modeling was only pursued for the analysis of that scale. Multiple regression analysis was used for the other three scales (STEBS, DTAS, and ATAS). Next, Level-1 or within-school models were created using several teacher-level predictors for the STOES scale.

School level predictors such as average socioeconomic status (ASES), percent White students and average NECAP scores were also tested in Level-2 of the model or between school model to examine the relationship between school characteristics and teacher scores. The percentage of students not participating in FRL program was used as a proxy for the schools’ average socioeconomic status. Harwell and LeBeau (2010) argue that FRL data is an insufficient measure of socioeconomic status, especially in
studies that use the data to control for effects, because many students are misclassified. In this study, ASES is not being used to control for effect and the additional data suggested by Harwell and LeBeau to enhance the reliability of the socioeconomic status variable were not available, therefore FRL was used as the proxy. Each school-level variable was added to the models individually to determine the extent to which they might explain the variance in teachers’ scores between schools.

*Multiple Regression Models*

In the case of three scales, there was no evidence of nesting, therefore I only used multiple regression models investigating teacher predictors. The statistical hypotheses being tested followed the correlation tradition. Since I am interested in determining if there is an actual relationship between the teachers’ scores on the scales and the independent predictors, I have chosen to test their shared variance.

H₀: \( \rho^2 = 0 \)

Null Hypotheses: Teachers’ beliefs about their self efficacy and the outcome expectancies independently share no variance with predictors in the study.

H₁: \( \rho^2 \neq 0 \)

Alternative Hypotheses: Teachers’ beliefs about their self efficacy and the outcome expectancies independently shares some statistically significant variance with predictors in the study.

For each test, diagnostic analyses were be performed in order to identify violations of ordinary least squares (OLS) assumptions: (1) the criterion regressed on predictor variables is linear, (2) the errors between observations are uncorrelated, (3)
residuals are normally distributed, independent and identically distributed, and (4) errors
are not correlated among predictor variables (Pedhazur, 1997). Simple regression
analyses were performed first to determine relationships between each predictor and the
criterion. Multiple regression models were then tested using a stepwise regression
method. This approach allowed me to determine the relative importance of each
predictor variable over and above other predictors.

Because significant collinearity existed among some predictors, related predictors
were blocked for inclusion in the models (Pedhauzer, 1997). The stepwise regression
method began with the inclusion of teacher background predictors one by one because
they were not highly correlated. Teacher predictors associated with perceptions of
themselves where then added as a block because they were highly correlated and they
were theoretically grouped as personal factors. Lastly, teacher predictors associated with
perceptions of their students were added as a block because they were also highly
correlated and they were theoretically grouped as external, student-based factors.
Individual models were created as each variable or block was added. A final model was
then produced which included only those predictors or blocks which had been found to
account for a statistically significant amount of the variance of the scale scores. Seven
models were therefore produced for each of the three scales. The Durbin-Watson test
statistic was used to test for the auto-correlation of the residuals for each model.

Chi-Square Testing

This study also set out to explore the question: What factors do teachers believe
most influence the frequency and quality of science whole-class discussions during
Because of the categorical nature of the teachers’ responses with respect to each limiting factor they perceive impact the frequency and quality of whole-class discussions, Pearson’s Chi-Square or the Goodness of Fit test was first used to determine teachers’ overall beliefs about the impact of the factors. Teacher responses to the each item were separated to create two groups. Those teachers rating the factor as not at all or somewhat important were combined into one group which considered the factor to be of low relative importance. Those teachers rating the factor as very or extremely important were placed in another group which considered the factor to be of high importance overall. Chi-square Goodness of Fit tests statistically investigated whether the frequency of responses differed among groups (Shavelson, 1996). The hypotheses associated with each test were

\[ H_0: \text{The observed distribution of frequencies is equally distributed for each category.} \]

\[ H_1: \text{the observed distribution of frequencies does not equal the expected, equal distribution between the categories.} \]

Only school variables were considered in the tests of independence. Teacher variables were not included in the crosstabulations.

Summary of Approach to Survey Data

In order to answer the research questions, selective data sources from the survey were used as either outcome variables or predictors during the analyses when modeling was appropriate. In the case of investigating the beliefs teachers’ had about the relative
importance of different factors on talk, chi-square tests were performed. A summary of the approaches taken to the survey data is provided in Table 3.2.

**Table 3.2. Summary of Analytical Approaches Taken With the Statewide Survey Data.**

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Sources</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>What factors are associated with secondary science teachers’ efficacy and outcome beliefs about engaging students in science talk during whole-class discussions?</td>
<td>Outcome Variables&lt;br&gt;STOES (Outcome Expectancy) scores&lt;br&gt;STEBs (Self-Efficacy) scores&lt;br&gt;Predictors&lt;br&gt;Background Question Responses&lt;br&gt;Context Question Responses&lt;br&gt;School-Level Predictors (SES, Demographic, and State Science Assessment Scores)</td>
<td>HLM&lt;br&gt;HLM/Multiple Regression</td>
</tr>
<tr>
<td>How do teachers perceive their role and the students’ role in authoritative and dialogic whole-class discussions?</td>
<td>Outcome Variables&lt;br&gt;DTAS (Dialogic) scores&lt;br&gt;ATAS (Authoritative) scores&lt;br&gt;Predictors&lt;br&gt;Background Question Responses&lt;br&gt;Context Questions Responses&lt;br&gt;School-Level Predictors (SES, Demographic, and State Science Assessment Scores)</td>
<td>HLM/Multiple Regression&lt;br&gt;HLM/Multiple Regression</td>
</tr>
<tr>
<td>What factors do teachers believe most influence the frequency and quality of science whole-class discussions during instruction?</td>
<td>Teachers Likert-Scale Ratings of different factors.&lt;br&gt;Expectations of Others&lt;br&gt;School Factors&lt;br&gt;Student Factors&lt;br&gt;Personal Constraints</td>
<td>Chi Square&lt;br&gt;Goodness of Fit Test&lt;br&gt;Test of Independence</td>
</tr>
</tbody>
</table>
Methods - Case Study

Participants

One secondary chemistry teacher, whose pseudonym will be Ms. Romac, and her students participated in a study to elucidate the data that was collected from the survey. Ms. Romac was chosen as a participant because of her interest in exploring talk within her classes. Her case is especially appropriate for this study because her class schedule included three different academically leveled classes: 10th grade general chemistry, 10th grade college preparatory chemistry, and 11th-12th grade Chemistry II, an elective honors level course. Students were placed in the classes as a result of previous achievement in science classes and teacher recommendation. For example, students placed in 10th grade college preparatory chemistry typically had higher science grades in 9th grade science compared to those students placed in 10th grade general chemistry. Parents had the ability to override the teacher recommendation for placement, however overrides are uncommon. Because differences may exist among students at different levels, incorporating this case while researching student beliefs about talk is an important component of this study.

Lesson Observations/Video Recordings

Three lessons in each class were observed and video recorded. Because the context and objectives of the teacher for any lesson play an important role in determining the type of student participation and the role of the teacher in the lesson (Mortimer & Scott, 2003), video recordings were made of teacher selected lessons because of her intention to focus on using talk as a tool for learning. When possible, lessons that
focused on the same content across class levels were recorded in order to facilitate comparisons. Prior to each lesson, the teacher was asked to complete a brief form outlining why the lesson was chosen, the goals she had for that particular lesson, in general, and the goals for science talk specifically. These questions were important because the teacher’s goals for each lesson impact the type of approach she will take to the discussion (Mortimer & Scott, 2003). Also, they served as points of discussion during the interview.

Teacher Interviews

A semi-structured interview protocol focusing on Ms. Romac’s goals, beliefs and understandings relative to science talk was conducted prior to taping the lessons (Appendix B). In subsequent interviews, the teacher was shown brief clips highlighting science talk in her classes and asked to talk about the choices that she made, her role in the discussion and her understandings of the type of science talk that students were engaged in (Appendix C). The video clips served as a source for stimulated recall by the teacher and provided specific contexts for the interview questions (Calderhead, 1981).

Three stimulated recall interviews were conducted with Ms. Romac. During each interview, one clip between 4-5 minutes in length from each class was shown. Clips were chosen according to how representative they were of the overall discussion that took place throughout the entire lesson or if they represented a unique event. For example, if the lesson was mostly authoritative in teacher approach, the clips for that class would predominantly reflect that approach. If a lesson had both authoritative and dialogic
approaches, balanced throughout, multiple clips for the lesson were chosen for the interview.

The teacher responded to each clip separately discussing her understanding of the types of interactions that were occurring as well as her beliefs about how well the approach served the purpose of the lesson. The teacher was then asked to compare across classes to discuss any possible factors that she thought may have influenced the differences she noticed among the clips across different classes.

**Student Surveys and Interviews**

All of the teacher’s students were surveyed prior to the recording of any lessons or interviews. The questionnaire consisted of two parts: the Science Talk Approach Scale (Appendix A4) that was also part of the statewide teacher survey and five open-ended response prompts (Appendix D). The open response questions focused on factors the students believed contributed to their willingness to participate in class discussions and the value they placed on this approach for learning science. Background information focusing on gender, ethnicity, family involvement in science-related careers and their grade in the class were also included for the sake of comparison as factors that may influence student approaches to talk (Appendix D).

Six students, two from each class, were interviewed to elaborate on the themes that emerged from the survey (Appendix E). Of those students who consented to participate in the study, one student from each class who contributed most in the class discussion either by frequency or length of response and one student who participated least during the lesson were interviewed. During the interview, they viewed the same
clips shown to Ms. Romac, however only the one associated with his or her class. The interviews took place within one week of the lesson. Six new students, two from each class, were chosen for each subsequent lesson using the same method as described. Eisenhardt (2002) suggests that between four and ten cases is formidable for developing theory to maximize the complexity in a way that is manageable. In this case there are 18 students in all, however there will be nine students representing the active participants and nine representing those students who did not frequently participate.

Qualitative Data Analysis

Video Recordings of Lessons. All video recordings were transcribed following Mercer’s (2005) methodology for sociocultural discourse analysis using “standard punctuation to represent the grammatical organization of the speech as interpreted by the researcher” (p. 147). Relevant non-verbal aspects of the class (i.e. writing, hand gestures) were included in italics when appropriate. To determine the extent of dialogic talk that was contributed by students, indicator words such as “because”, “I think”, “If”, “Why”, “Which”, “What”, “You”, “Agree”, and “So, were counted when they appeared in student utterances that were associated with reasoning (Mercer & Littleton, 2007). These words were coded when they were associated with student meaning making such as when students used them in response to the teacher or other students. The indicator words were not counted when they were associated with non-reasoning type requests like “What did you say?” A dialogic response might be “What would happen if…?” or “What you mean is…?” The frequency measures of these words were used as indicators of students’
attempts to construct meaning during discussion and their frequencies were compared across lessons and classes.

Teacher and student questions were also coded. For the teacher, I focused primarily on the types of questions that she used to initiate student participation in the dialogue as well as her reaction to the students’ responses (see Table 3.3). The coding scheme is based on the Blosser (1973) and Chin (2007) questioning frameworks.
<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managerial</td>
<td>Non-content, class organizing questions</td>
<td>“Can you please move your seat?”</td>
</tr>
<tr>
<td>(Blosser, 1973)</td>
<td>Questions that ask about a student’s disposition or a non-content, non-class related question.</td>
<td>“Are you feeling better?” “How was your weekend?”</td>
</tr>
<tr>
<td>Personal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhetorical</td>
<td>Questions used to reinforce a point. A response is not expected. Teacher continues talking after the question.</td>
<td>“Do you know what I mean?” It is when…. “Okay?”</td>
</tr>
<tr>
<td>(Blosser, 1973)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeat</td>
<td>Asking for a student to repeat or restate a prior statement.</td>
<td>“Can you say that again?”</td>
</tr>
<tr>
<td>Initiating - Closed</td>
<td>Questions with responses that are limited to fact or are used to focus thinking towards a limited set of right answers. Usually recall, identify, classify, apply. Initiates a new thought or sequence.</td>
<td>“How many electrons does a chorine atom have?”</td>
</tr>
<tr>
<td>(Blosser, 1973)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumping – Closed</td>
<td>Questions that guide students towards a specific way of thinking. Used after a student has responded. No obvious evaluation or elaboration by the teacher is evident.</td>
<td>Student- “I have 180 amu.” Teacher – “and what does that represent?” Student – “180 atoms” Teacher – “When they bonded together, what did they become?”</td>
</tr>
<tr>
<td>(Chin, 2007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiating - Open</td>
<td>Questions that allow for more than one interpretation or response such that thinking is not restricted to one expected answer. Asks for students to infer, justify, design, judge. Initiates a new thought or sequence.</td>
<td>“Can you think of something in your everyday life that would be similar to….?” “What do you notice when you look at this figure?”</td>
</tr>
<tr>
<td>(Blosser, 1973)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Elaboration - Open
Questions that ask a student to explain their thinking about how they came to an answer.
“Why did you say that?”
“What do you mean by that?”

Reflective Toss – Open
Questions that ask students to remark on the given question of another student response without prior teacher evaluation.
“Does anyone want to respond to that?”

(Chin, 2007; van Zee & Minstrell, 1997)

A different coding scheme was used to code student questions given that they were inherently different than those the teacher was asking. This coding scheme was developed following an iterative analysis of the transcripts (Miles & Huberman, 1994). As was done for the teacher’s questions, all student questions were coded. Table 3.4 elucidates the coding scheme.

**Table 3.4. Student’s Question Coding Scheme**

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeat</td>
<td>Student did not hear what the teacher had said, therefore asks for her to repeat it.</td>
<td>“Did you say 11?”</td>
</tr>
<tr>
<td>Clarification Question</td>
<td>Student asks a teacher to elaborate or clarify a statement or procedure.</td>
<td>“What did you mean by…?”</td>
</tr>
<tr>
<td>Extension Question</td>
<td>Student asks a question that is related to previous experience or knowledge.</td>
<td>“Is that like when I mix vinegar and baking soda and bubbles form?”</td>
</tr>
<tr>
<td>Question Answer</td>
<td>Student answers a question but in the form of a question.</td>
<td>Teacher – “What color is representing the neutrons?” Black?</td>
</tr>
<tr>
<td>Other</td>
<td>Personal – asking to leave class Evaluation – asking if the answer is right? Managerial – Asking if something should be written down</td>
<td></td>
</tr>
</tbody>
</table>

60
Two raters were involved in the coding process of all the questions set forth by the teacher during the lesson (Maxwell, 2002). Both raters coded one lesson transcript for calibration purposes. The approach was iterative such that the coding scheme was revised as a result of the data analysis (Miles & Huberman, 1994). After establishing the coding scheme, one rater coded all transcripts while the second rater coded 20% of the all lessons. The interrater reliability was calculated by percent agreement. The percent agreement was 80%. Any disagreements were resolved through discussion. The frequencies of the teacher’s and students’ questions were then compared across classes to the frequency of student dialogic indicator words using simple regression.

Teacher Interviews and Surveys. Interview responses were transcribed following the method described for lesson transcripts. Prior to further analysis, interview transcripts were given to Ms. Romac for verification that her beliefs were properly captured. Ms. Romac’s interview responses as captured on the transcripts were analyzed thematically (Strauss & Corbin, 1990). I coded the transcripts focusing on statements that were related to four questions: (a) What is the main purpose of whole-class discussions? (b) What is the role of the teacher in whole-class discussions?, (c) What is the role of the student in whole-class discussions?, and (d) What factors are influencing the interactions that occur during whole-class discussions? Statements capturing Ms. Romac’s beliefs about dialogic science talk and her role in this type of talk were coded and triangulated amongst the various sources of interview data and compared to her scores on the scales and factor items of the statewide survey.
Student Surveys and Interviews. Student survey responses to the Science Talk Approach Scales were combined separately to create two measures of student beliefs about the features of effective science talk. Factor analysis of student responses to the Science Talk Approach scale was performed as described previously for the teacher survey. Because the factor loadings for the student responses were substantially different from the teachers’ results and suggested that several constructs were in play, subsequent analyses focused on Chi-Square Goodness of Fit tests and Test of Independence tests of each individual item. The intention was to determine if a significant difference existed among the different classes.

Student open response questions and transcribed interview responses were analyzed thematically using open coding (Strauss & Corbin, 1990). The main focus of the analysis revolved around six themes: the purpose of talk, the role of the teacher, the role of students, references to personal qualities, views about peer social interactions during class discussions, and comparisons that were made between talking in science versus other classes. Responses were summarized and compiled into tables for each student which was identified by class level and by tendency to participate in discussions (Yin, 1994). The prevalence of common statements relative to student beliefs across about participating in science talk were determined and compared across classes.

Development of the case study

After the data had been reduced as explained in previous sections, pattern-matching or triangulation across the data sources focusing on the beliefs the teacher and students expressed about their roles and how they framed the discussions was performed.
(Yin, 1994). Data was triangulated by lesson in terms of transcript coding, teacher interview responses and student responses. Data was also compared across teacher interviews in order to establish consistent beliefs about whole-class discussions. Student interview and survey responses were compared across class levels and frequency of talk. Themes which appeared to be most prevalent, meaning that they appeared most often across data sources and participants, were then presented in the description of the case study (Rossman & Rallis, 2003).

Taken as a whole, the case studies serve to portray a more complete understanding of the factors that influence whole-class science discussions. Because dialogic interactions require both teacher and student openness to that type of participation structure, the interviews and surveys allow for a deeper exploration of the beliefs all the stakeholders bring to this aspect of class instruction and possibly some insight into how those beliefs interact to restrict or support dialogic talk.

Summary

The main question of this dissertation is *What are the factors that influence teachers’ and students’ beliefs about engaging in science talk during whole class discussions?* The methods used to explore this question at both a broad scale, using the statewide survey, and a more focused scale at the classroom level has been chosen in order to develop the most comprehensive description possible of teachers’ and students’ beliefs.
CHAPTER FOUR: TEACHER BELIEFS ABOUT SCIENCE TALK DURING
WHOLE-CLASS DISCUSSIONS – STATEWIDE SURVEY RESULTS

To develop a comprehensive understanding of secondary science teachers’ beliefs about science talk during whole-class discussions, I began by examining science teachers’ perceptions and beliefs based on their responses to the statewide survey. First, I present the descriptive statistics describing teachers’ responses to the Outcome Expectancy scale (STOES), the Efficacy Scale (STEBS), the Authoritative Approach Scale (ATAS) and the Dialogic Approach Scale (DTAS). Second, I explore the relationships among scale scores and both school and teacher predictors by building hierarchical linear models and multiple regression models when appropriate. Finally, I present chi-square statistics of teacher beliefs about the relative importance of different factors influencing the frequency and quality of science talk during whole-class discussions in which the purpose is to develop students’ understandings of a scientific concept. These analyses enable me to address my first three research questions:

• What factors are associated with secondary science teacher efficacy and outcome beliefs about engaging students in science talk during whole-class discussions?

• How do teachers perceive their role and the students’ role in authoritative and dialogic whole-class discussions?

• What factors do teachers believe most influence the frequency and quality of science whole-class discussions during instruction?
Descriptive Statistics of Survey Responses

General Respondent Statistics

Forty-five percent of the Rhode Island secondary science teachers (n=185) responded to the survey. The mean teaching experience for the sample was 13.02 years (SD = 7.96). Only 4% of the teachers who responded had non-science undergraduate degrees (n = 7). Most respondents reported having a bachelor degree in a scientific discipline: 51% Biology, 16% Chemistry, 9% Physics, and 18% in another science discipline. Also, 64% of the teachers reported having an advanced degree. While most of these teachers possessed their Master’s degrees, six teachers had a PhD.

Response rates by school ranged from 0 – 92% with a mean response rate of 54% per school (SD = 0.20). Only one school had no teacher respondents. A higher response rate was obtained from those schools reporting a higher percentage of White students. This may be the result of a lower response rate by teachers in one specific large urban district. At the time this survey was distributed, termination letters had been given to all of the teachers in the district for the upcoming school year. This caused tensions in the district and may be one explanation for the lower response rate from these schools.

Approximately two-thirds of the respondents (n = 121) estimated that they spent at least 50% of class time engaged in whole-class discussion with 26 teachers estimating that they spent 80-100% of instructional time engaged in whole-class discussions. Forty percent of the teachers reported never having taken a course or workshop focused on guiding student science talk during whole-class discussions. One teacher commented in fact that professional development he had participated in focused on cooperative learning.
and methods for differentiating materials, which he viewed as being against the use of whole-class discussion as a teaching strategy. The predominance of class time dedicated to whole-class discussions as reported by these secondary science teachers would suggest that this approach to instruction is utilized frequently, while many teachers have had limited opportunities to explore the facets of whole-class discussion. A summary of these statistics can be found in Table 4.1.

Table 4.1. Descriptive statistics of teacher characteristics.

<table>
<thead>
<tr>
<th>Sample Mean years of Teaching Experience</th>
<th>13.02 (7.96)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate Degree</td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>51%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>16%</td>
</tr>
<tr>
<td>Physics</td>
<td>9%</td>
</tr>
<tr>
<td>Other Science</td>
<td>18%</td>
</tr>
<tr>
<td>Advanced Degree Attainment</td>
<td>64%</td>
</tr>
<tr>
<td>Time Spent Engaged in Whole Class Discussions</td>
<td></td>
</tr>
<tr>
<td>Less than 50%</td>
<td>33%</td>
</tr>
<tr>
<td>At least 50%</td>
<td>67%</td>
</tr>
<tr>
<td>Participation in Coursework/Workshops focused on Guiding Talk during Whole Class Discussions</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>40%</td>
</tr>
<tr>
<td>1 or more</td>
<td>60%</td>
</tr>
</tbody>
</table>

Descriptive Statistics of STOES Scores

The Science Talk Outcome Expectancy Beliefs Scale (STOES) was used to explore teachers’ beliefs about the effectiveness of whole-class discussion to bring about student learning. The scale consisted of six items. Each teacher’s score was equal to the average score attained for all of the items. The average score for teachers on this scale
was 5.83/10.00 (SD = 1.50) suggesting a moderate belief in ability of whole-class
discussions to bring about student science learning. The range of scores across all
respondents was from 1.00/10.00, suggesting very low expectations of student learning
from whole-class discussions, to 10.00/10.00, suggesting high expectations that whole-
class discussions will bring about positive learning outcomes. The responses on this
scale were consistent with a normal distribution as depicted in Figure 4.1.

![Distribution of Teacher STOES scores](image)

*Figure 4.1. Distribution of Teacher STOES scores*

*Descriptive statistics of STEBS Scores*

To investigate teacher science talk efficacy beliefs within the context of whole-
class discussions, Science Talk Efficacy Beliefs Scale (STEBS) scores were calculated
such that the respondents’ scores on this scale was equal to the average score calculated of their responses to the nine items. The average scale score for teachers was $6.66/10.00$ ($SD = 1.31$) suggesting slightly positive notions of efficacy during whole-class discussions for the sample. The range of scores across all respondents was from $2.78/10.00$ to $10.00/10.00$. The responses on this scale were consistent with an approximately normal distribution as depicted in Figure 4.2.

*Figure 4.2. Distribution of Teacher STEBS scores.*
Teacher beliefs about the important features associated with effective science talk during whole-class discussions in which the purpose is to develop students’ understandings of a scientific concept were measured by two scales: the Dialogic Talk Approach Scale (DTAS) and the Authoritative Talk Approach Scale (ATAS).

The DTAS included features of talk that highlighted co-participation between teacher and students within the context of multiple ideas. The mean score for teachers on this 7-item scale was 2.31/3.00 (SD = 0.42). Unlike the two previous scales, the Likert scale associated with each item ranged from 0 signifying no importance to 3 signifying extreme importance. The mean score of the respondents fell between rating the dialogic features of talk as being very to extremely important overall. The range of scale scores was from 0.71/3.00 to 3.00/3.00. This scale showed a distribution that was approximately normal overall (see Figure 4.3).
Figure 4.3. Distribution of average DTAS scores.

Item means ranged from 1.87/3.00 on item D11 “Students talk directly to each other” to 2.52/3.00 on item D10 “Students provide reasoning when they contribute to discussions”. All item means besides D11 were ranked as being very to extremely important in developing students’ understandings of science concepts. Descriptive statistics for each item in the scale is presented in Table 4.2.
Table 4.2. Descriptive statistics of DTAS items.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>Teacher asks students to clarify or elaborate on their responses.</td>
<td>2.49 (0.62)</td>
</tr>
<tr>
<td>D3</td>
<td>Teacher and students build on each other’s ideas.</td>
<td>2.43 (0.59)</td>
</tr>
<tr>
<td>D5</td>
<td>Students contribute personal points of view.</td>
<td>2.05 (0.68)</td>
</tr>
<tr>
<td>D8</td>
<td>Teacher is open to different point of view.</td>
<td>2.49 (0.61)</td>
</tr>
<tr>
<td>D9</td>
<td>Students initiate new ideas into the discussion.</td>
<td>2.33 (0.66)</td>
</tr>
<tr>
<td>D10</td>
<td>Students provide reasoning when they contribute to discussions.</td>
<td>2.52 (0.59)</td>
</tr>
<tr>
<td>D11</td>
<td>Students talk directly to each other.</td>
<td>1.87 (0.78)</td>
</tr>
</tbody>
</table>

The Authoritative Talk Approach Scale included features of talk that were more teacher-centered and restricted to the science point of view. Teachers’ scores were calculated by the average score of all six items in the scale. Like the previous dialogic scale, the Likert scale associated with each item ranged from 0 signifying no importance to 3 signifying extreme importance. The mean score for teachers on this 6-item scale was 1.43/3.00 (SD = 0.45). This average fell between rating the authoritative features of talk as being somewhat to very important overall. The range of scale scores was from 0.17/3.00 to 3.00/3.00. This scale showed an approximately normal distribution (see Figure 4.4).
Item means for this scale where all lower than those of the DTAS. Item A13 which read “Students contribute to the discussion only when called upon by a teacher” had an average item mean of 0.84 placing it as the least important feature of effective whole-class discussions. Item A1 with a mean average of 2.09/3.00 was the highest ranking item on the scale suggesting that teachers thought that it was at least very important that a “Teacher evaluates and provides feedback immediately after student contributions” during effective whole-class discussions. Overall the items in this scale where considered to be less important than those on the DTAS. Descriptive statistics for each item in the ATAS is presented in Table 4.2.
Hierarchical Linear Models

Hierarchical linear modeling was initially undertaken to examine the possible relationship among various predictors and the teachers’ scores on the four scales. This approach was chosen given that teachers are nested in schools, therefore they may be influenced by group predictors at the school level that further contribute to the explanation of variance noted in the scale scores. Also, the analysis served to control for statistical clustering (i.e., correlated clustering observations within clusters). Level 1 and Level 2 Models were then tested to explain the responses for those scales that had statistically significant variance at the school level.

Analysis of the fully unconditional models associated with each scale demonstrates that only the outcome expectancy scale scores (STOES) showed that there was some variation among schools (i.e., there was a clustering effect), $\chi^2 (df=29) = 52.05, p = 0.006$ (see Table 4.4). The calculated Intraclass Correlation Coefficient (ICC) for this model suggests that 13% of the variance in STOES scores existed between schools. The low reliability estimate ($\lambda = 0.44$) associated with this model is cause for

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>2.09 (0.79)</td>
</tr>
<tr>
<td>A4</td>
<td>1.16 (0.70)</td>
</tr>
<tr>
<td>A6</td>
<td>0.90 (0.73)</td>
</tr>
<tr>
<td>A7</td>
<td>1.91 (0.74)</td>
</tr>
<tr>
<td>A12</td>
<td>1.70 (0.76)</td>
</tr>
<tr>
<td>A13</td>
<td>0.84 (0.81)</td>
</tr>
</tbody>
</table>

Table 4.3. Descriptive statistics of ATAS items.
concern. The inclusion of the small number of teachers for some schools (n = 3) which may have included a high degree of variation within the groups may account for this. That being said, the fact that the reliability associated with the outcome expectancy scale (STOES) was so much greater than the other scales suggests that there may be variance at the school level that should be considered therefore within-school and between-school models were tested for the STOES scale. Fully Unconditional model specifications were Level-1 Model

$$\text{Predicted Scale Score} = \beta_0 + r$$  \hspace{1cm} (1)

Level-2 Model

$$\beta_0 = \gamma_{00} + \mu_0$$  \hspace{1cm} (2)
Table 4.4. Fully Unconditional Models: Partitioning of Variance in STOES, STEBS, DTAS, and ATAS Scores.

<table>
<thead>
<tr>
<th>Outcome Expectancy Scale Score (STOES)</th>
<th>Efficacy Scale Score (STEBS)</th>
<th>Dialogic Scale Score (DTAS)</th>
<th>Authoritative Scale Score (ATAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance between schools (tau)</td>
<td>0.2859</td>
<td>0.0080</td>
<td>0.0003</td>
</tr>
<tr>
<td>Variance within schools (sigma-squared)</td>
<td>1.88</td>
<td>1.67</td>
<td>0.19</td>
</tr>
<tr>
<td>Intercept Reliability</td>
<td>0.44</td>
<td>0.025</td>
<td>0.009</td>
</tr>
<tr>
<td>Proportion of variability between schools (intra-class-correlation)</td>
<td>0.13</td>
<td>0.005</td>
<td>0.017</td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>52.05</td>
<td>33.32</td>
<td>30.21</td>
</tr>
<tr>
<td>df</td>
<td>29</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>p</td>
<td>0.006</td>
<td>0.265</td>
<td>0.403</td>
</tr>
</tbody>
</table>

The addition of all teacher-level predictors in Model 1 resulted in a decrease in the intercept reliability of the Model to make it 0.29 (see Table 4.5). This was the case for the subsequent models which also included school-level predictors. The reliabilities of the intercepts for Models 2, 3, and 4 were all approximately 0.30. Furthermore, none of the models accounted for statistically significant variance of the STOES scores. In fact, the residual variance within was calculated to be -4% (see Table 4.6). Negative variance explained can arise when truly nonsignificant predictors are entered into the model (Raudenbush & Bryk, 2002).
Table 4.5. Results from HLM Predicting Science Teachers' Outcome Expectancy Scores (STOES).

<table>
<thead>
<tr>
<th>Fixed Components</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.93(0.14)**</td>
<td>5.94(0.14)**</td>
<td>5.93(0.14)**</td>
<td>5.94(0.14)**</td>
</tr>
</tbody>
</table>

### Teacher-Level Predictors

#### Teacher Background Predictors

- Teaching Experience (Yrs.)
  - Model 1: 0.003(0.02)
  - Model 2: 0.002(0.02)
  - Model 3: 0.003(0.02)
  - Model 4: 0.002(0.02)

- Undergraduate Degree (Biology vs. Physical Science)
  - Model 1: 0.07(0.25)
  - Model 2: 0.07(0.25)
  - Model 3: 0.07(0.25)
  - Model 4: 0.06(0.25)

- Undergraduate Degree (Biology vs. Non-Science)
  - Model 1: 0.04(0.59)
  - Model 2: 0.03(0.59)
  - Model 3: 0.04(0.59)
  - Model 4: 0.04(0.59)

- Graduate Degree (1 = graduate degree, 0 = none)
  - Model 1: -0.16(0.26)
  - Model 2: -0.17(0.26)
  - Model 3: -0.16(0.26)
  - Model 4: -0.16(0.26)

- Course/Workshop focusing on Science Talk/Discussions (1 = at least one, 0 = none)
  - Model 1: -0.06(0.26)
  - Model 2: -0.06(0.26)
  - Model 3: -0.07(0.26)
  - Model 4: -0.06(0.26)

#### Teacher Perceptions of Themselves

- Teacher Content Knowledge
  - Model 1: 0.10(0.14)
  - Model 2: 0.10(0.14)
  - Model 3: 0.09(0.14)
  - Model 4: 0.10(0.14)

  (10 = Superior, 0 = Problematic)

- Teacher Knowledge of Different Approaches to Guide Talk
  - Model 1: 0.08(0.11)
  - Model 2: 0.08(0.11)
  - Model 3: 0.08(0.11)
  - Model 4: 0.08(0.11)

  (10 Superior, 0 = Problematic)

#### Teacher Perceptions of Students

- Student Academic Ability/Content Knowledge
  - Model 1: -0.04(0.14)
  - Model 2: -0.04(0.14)
  - Model 3: -0.04(0.14)
  - Model 4: -0.04(0.14)

  (10 Superior, 0 = Problematic)

- Student Motivation/Behavior
  - Model 1: 0.20(0.11)
  - Model 2: 0.20(0.11)
  - Model 3: 0.20(0.11)
  - Model 4: 0.20(0.11)

  (10 = Superior, 0 = Problematic)

- Student English Language Proficiency
  - Model 1: -0.14(0.09)
  - Model 2: -0.14(0.09)
  - Model 3: -0.14(0.09)
  - Model 4: -0.15(0.09)

  (10 = Superior, 0 = Problematic)

### School-Level Predictors

- % Students not on FRL
  - Model 1: 0.09(0.67)

- % White Students
  - Model 1: 0.02(0.43)

- School Average Score on NECAP Achievement Test
  - Model 1: 0.003(0.01)

***p < 0.001, **p < 0.01, *p < 0.05, ~p < 0.10
HLM Model 1

Level-1

\[ \text{STOES}_{ij} = \beta_{0j} + 0.003(\text{exp}) + 0.07(\text{PSDeg}) + 0.04(\text{NSDeg}) - 0.16(\text{Graddeg}) - 0.06(\text{cwshp}) + 0.10(\text{contkn}) + 0.08(\text{pedkn}) - 0.04(\text{studability}) + 0.20(\text{studmot}) - 0.14(\text{ELL}) + r_{ij} \]  

Level-2

\[ \beta_{0j} = 5.93 + \mu_0 \]  

(3)

(4)

HLM Model 2

Level-1

\[ \text{STOES}_{ij} = \beta_{0j} + 0.002(\text{exp}) + 0.07(\text{PSDeg}) + 0.03(\text{NSDeg}) - 0.17(\text{Graddeg}) - 0.06(\text{cwshp}) + 0.10(\text{contkn}) + 0.08(\text{pedkn}) - 0.04(\text{studability}) + 0.20(\text{studmot}) - 0.14(\text{ELL}) + r_{ij} \]  

Level-2

\[ \beta_{0j} = 5.94 + 0.09(\text{ARSINSES}) + \mu_0 \]  

(5)

(6)
Model 3
Level-1
\[
\text{STOES}_{ij} = \beta_{0j} + 0.003(\text{exp}) + 0.07(\text{PSDeg}) + 0.04(\text{NSDeg}) - 0.16(\text{Graddeg}) - 0.07(\text{cwshp}) + 0.09(\text{contkn}) + 0.08(\text{pedkn}) - 0.04(\text{studability}) + 0.20(\text{studmot}) - 0.14(\text{ELL}) + r_{ij}
\]  
\tag{7}

Level-2
\[
\beta_{0j} = 5.93 + 0.02(\text{ARSINPER}) + \mu_0
\]  
\tag{8}

Model 4
Level-1
\[
\text{STOES}_{ij} = \beta_{0j} + 0.002(\text{exp}) + 0.06(\text{PSDeg}) + 0.04(\text{NSDeg}) - 0.16(\text{Graddeg}) - 0.06(\text{cwshp}) + 0.10(\text{contkn}) + 0.08(\text{pedkn}) - 0.04(\text{studability}) + 0.20(\text{studmot}) - 0.15(\text{ELL}) + r_{ij}
\]  
\tag{9}

Level-2
\[
\beta_{0j} = 5.94 + 0.003(\text{NECAP}) + \mu_0
\]  
\tag{10}
The addition of school-level predictors at level 2 also produced nonsignificant results: socioeconomic status as measured by percent of student on free or reduced lunch \((p = 0.90)\), percent of White students \((p = 0.97)\), and average score on state science test \((p = 0.77)\). These models failed to account for significant variance in the outcome expectancy scores, however, the low reliability of the intercept makes it difficult to know if the predictors are truly insignificant.

*Table 4.6. Summary of Variance Components for Hierarchical Linear Models of STOES.*

<table>
<thead>
<tr>
<th>Random Effects</th>
<th>Variance Available % Explained</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual Variance Within (Level 1)</td>
<td>87% ...at Level-1</td>
<td>-4%</td>
<td>-4%</td>
<td>-4%</td>
<td>-4%</td>
</tr>
<tr>
<td>Residual Variance Between – ICC (Level 2)</td>
<td>13% ...at Level-2</td>
<td>37%</td>
<td>35%</td>
<td>38%</td>
<td>...Total 0%</td>
</tr>
</tbody>
</table>

◊ Calculated by setting residual variance within to 0%.

In all four models only the coefficient for teacher perceptions of student motivation appeared to be possibly related to teacher beliefs about the ability of whole-class discussions to bring about student learning \((p < 0.10)\). To investigate further, HLM was used to test models using only teacher perceptions of student motivation at Level-1 (see Table 4.7). As a result, the reliability of the intercepts increased above 0.40, which is still low. Including only the teachers’ perceptions of students’ motivation in Level-1 produced a positive residual variance within. The practical significance of this predictor overall is minimal however given that for every one point increase in the teachers’ rating
of student motivation, the resulting STOES score only increased by 0.14 points. The removal of the other non-significant predictors however caused the residual variance between schools to now produce a negative residual variance (see Table 4.8). The lack of significance may be due to the low power associated with the study.

Table 4.7. Coefficients for teacher perceptions of student motivation and school characteristics using HLM predicting Science Teachers’ Outcome Expectancy Scores (STOES).

<table>
<thead>
<tr>
<th>Fixed Components</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.93***</td>
<td>5.14***</td>
<td>5.93***</td>
<td>5.93***</td>
</tr>
<tr>
<td>Teacher-Level Predictors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Motivation/Behavior</td>
<td>0.14*</td>
<td>0.14*</td>
<td>0.14*</td>
<td>0.14*</td>
</tr>
<tr>
<td>(10 = Superior, 0 = Problematic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School-Level Predictors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Students not on FRL</td>
<td>-0.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% White Students</td>
<td></td>
<td>-0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Average Score on NECAP</td>
<td></td>
<td></td>
<td>-0.001</td>
<td></td>
</tr>
<tr>
<td>Achievement Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***p < 0.001, **p < 0.01, *p < 0.05, ~p < 0.10

HLM Model 1

Level-1

\[ \text{STOES}_{ij} = \beta_{0j} + 0.20(\text{studmot}) + r_{ij} \]  

(11)

Level-2

\[ \beta_{0j} = 5.93 + \mu_0 \]  

(12)
HLM Model 2

Level-1

$$STOES_{ij} = \beta_{0j} + 0.20(studmot) + r_{ij}$$  \hspace{1cm} (13)

Level II

$$\beta_{0j} = 5.13 - 0.21(ARSINSES) + \mu_0$$  \hspace{1cm} (14)

HLM Model 3

Level-1

$$STOES_{ij} = \beta_{0j} + 0.20(studmot) + r_{ij}$$  \hspace{1cm} (15)

Level-2

$$\beta_{0j} = 5.93 - 0.18(ARSINPER) + \mu_0$$  \hspace{1cm} (16)

HLM Model 4

Level-1

$$STOES_{ij} = \beta_{0j} + 0.20(studmot) + r_{ij}$$  \hspace{1cm} (17)

Level-2

$$\beta_{0j} = 5.93 - 0.0001(NECAP) + \mu_0$$  \hspace{1cm} (18)
Given the limited number of teachers in many of the school groups and the fact that many schools associated with lower socioeconomic status were removed from the analysis because fewer than three teachers responded, the results of this analysis are inconclusive. This reduction in the number of schools and teachers in the study reduced the power or the ability to note significant differences that exist among the respondents. Although there was 13% of variance that could be accounted for at the school level, the school level predictors that were chosen were not significant predictors of that variance. The low reliability of the intercepts for each model makes it difficult to make any strong conclusions. While the possibility exists that other factors like school culture or even the culture of the science department at each school may influence teacher outcome expectancy beliefs about the effectiveness of whole-class discussions, these characteristics were not measured and could not be included in the model. Future research should consider what other school level characteristics may be associated with teachers’ outcome expectancy for full class discussions.
Interestingly, there did not appear to be apparent nesting within schools associated with the efficacy scale scores (STEBS), the dialogic approach scale scores (DTAS), or the authoritative scale scores (ATAS) as shown in Table 4.4. These results would suggest that teachers’ beliefs about their efficacy and their beliefs about the approaches that are most important for productive whole-class discussions may be independent of their school. Because no statistically significant variance between schools was apparent with the responses to these three scales, multiple regression was utilized to determine the possible relationships among teacher-level predictors and these scales.

**Regression Models**

*Factors Related to Science Talk Efficacy Beliefs Scale Scores (STEBS)*

Several factors were related to teachers’ beliefs about their efficacy in conducting productive whole-class discussions. Seven overall models were created. A stepwise regression method began with the inclusion of teacher background predictors one by one. Teacher predictors associated with perceptions of themselves were then added as a block because they theoretically related and highly correlated. Similarly, teacher predictors associated with perceptions of their students were added as a block, because these were also theoretically related and highly correlated. Individual models were created as each variable or block was added. A final model was then produced which included only those predictors or blocks which were found to account for a statistically significant amount of the variance of the scale scores.

Although all predictors of interest were added to the models, only three emerged as statistically significant predictors of teacher efficacy beliefs: participation in
coursework/workshops focused on discussions, teacher rating of their content knowledge, and teacher rating of their knowledge of science talk strategies (see Table 4.9). The final model (Model 7) accounted for 38% of the variation in teacher scores, \( F(3,174) = 37.36, p < 0.001 \). The equation is presented below.

\[
\hat{Y} = 1.13 + 0.51(\text{coursework/workshop}) + 0.24(\text{content knowledge}) + 0.37(\text{knowledge of strategies})
\] (19)

Participation in at least one course or workshop that focused on approaches to guiding talk during whole-class discussion was associated with a higher efficacy score. Although the coefficient suggests that the score only increases by 0.5 points on a 10-point scale, this is practically significant because 40% of teachers in this study stated they had never taken a course or workshop which elucidated strategies towards guiding talk. Because of this high number, this variable was treated as a binary code as opposed to using the number of courses teachers had participated in. It is possible that participation in multiple courses may actually have a stronger relationship with teacher efficacy, but due to the limitations of this study, it was not possible to investigate this further. If one considers coursework/workshop participation alone in a simple regression model, this variable accounts for 8.5% of the variation in efficacy scores with \( F(1, 176) = 16.388, p < 0.001 \). The variable therefore has a significant relationship with teacher feelings of efficacy and should be considered when developing models of teacher efficacy towards whole-class discussions.

Teacher ratings of their content knowledge and knowledge of different approaches to talk were also significant predictors of their efficacy score. This serves less of a practical purpose because in effect these predictors are self-perceptions which
were not quantified by a more subjective measurement like number of courses taken in the subject area or scores on subject tests. At its most fundamental level, those teachers who rated themselves higher in content knowledge and knowledge of different strategies also scored higher on the efficacy scale. This may have been confounded by specific items on the efficacy scale that referred to teacher knowledge of science concepts and steps necessary to guide talk in a specific direction. The importance of these predictors in the model are therefore questionable. However, this suggests that perceptions of pedagogical knowledge relative to whole-class discussions may be related to the teachers’ self-efficacy.

If one considers Model 4 in which only subjectively measurable teacher predictors are included, the years of teaching experience, possession of a graduate degree and participation in coursework/workshops are the statistically significant predictors of efficacy score $F(5, 161) = 5.66, p < 0.001$ (see Table 4.8). The equation for Model 4 is

$$STEBS = 5.60 + 0.03(Experience) - 0.05(PSdegree) + 0.50(NonSdegree) + 0.41(Gradeg) + 0.63(coursework/workshop) + \text{error} \quad (20)$$

While years of experience is positively related to efficacy score, the coefficient is for all practical purposes quite low. In this case, 20 years of experience adds 0.6 of a point to the efficacy score, which is the same that is accomplished with participation in at least one course or workshops focused on guiding talk during whole-class discussions. Furthermore, the inclusion of the coursework variable accounted for an additional 5% of the variation in scores once the other two predictors were accounted for and produced a statistically significant $F$-change $(1, 161) = 10.30, p = 0.002$. This further supports the
idea that inclusion of coursework/workshop participation is important in modeling teacher efficacy in guiding whole-class discussions.

It is also interesting to note that in model 4, the possession of a graduate degree is also related to higher efficacy scores. One might initially think that graduate degree possession and participation in coursework about guiding talk may be highly correlated given that most of the graduate degrees were in science education, however these two predictors are not correlated at all (r = -0.08, p = 0.912). This would suggest that discussion of approaches to guiding talk during whole-class discussions was not a standard element of teacher preparation programs for the teachers in this study.

The variables that were not significant predictors of efficacy score are equally interesting to consider. Teacher undergraduate degree did not contribute significantly to predicting STEBS scores suggesting that efficacy beliefs about guiding talk are independent of the science discipline. Of greater interest is perhaps the fact that teachers’ beliefs about efficacy in this study were not related to perceptions about students’ academic abilities, motivation/behavior, or English Language proficiency as shown in Model 6 (see Table 4.8). Efficacy as measured by the present scale was therefore only dependent on teacher predictors and not student characteristics.
Table 4.9. Regression Models predicting Science Talk Efficacy Beliefs Scale (STEBS) Scores.

<table>
<thead>
<tr>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>6.07(0.19)***</td>
<td>6.09(0.21)***</td>
<td>5.92(0.24)***</td>
<td>5.60(0.25)***</td>
<td>1.20(0.59)*</td>
<td>1.05(0.60)</td>
</tr>
<tr>
<td><strong>Teacher Background Predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Experience (Yrs.)</td>
<td>0.04(0.01)***</td>
<td>0.04(0.12)***</td>
<td>0.04(0.13)**</td>
<td>0.03(0.01)*</td>
<td>0.01(0.01)</td>
<td>0.01(0.01)</td>
</tr>
<tr>
<td>Undergraduate Degree (Biology vs. Physical Science)</td>
<td>-0.07(0.20)</td>
<td>-0.10(0.20)</td>
<td>-0.05(0.20)</td>
<td>-0.20(0.17)</td>
<td>-0.18(0.17)</td>
<td></td>
</tr>
<tr>
<td>Undergraduate Degree (Biology vs. Non-Science)</td>
<td>0.38(0.50)</td>
<td>0.36(0.49)</td>
<td>0.50(0.48)</td>
<td>0.12(0.41)</td>
<td>0.16(0.41)</td>
<td></td>
</tr>
<tr>
<td>Graduate Degree (1 = graduate degree, 0 = none)</td>
<td>0.39(0.21)</td>
<td>0.41(0.21)*</td>
<td>0.22(0.18)</td>
<td>0.25(0.18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course/Workshop focusing on Science Talk/Discussions (1 = at least one, 0 = none)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Teacher Perceptions of Themselves</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Content Knowledge (10 = Superior, 0 = Problematic)</td>
<td></td>
<td></td>
<td></td>
<td>0.27(0.08)** 0.27(0.08)** 0.24(0.08)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Knowledge of Different Approaches to Guide Talk (10 Superior, 0 = Problematic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Teacher Perceptions of Students</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Academic Ability/Content Knowledge (10 Superior, 0 = Problematic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Motivation/Behavior (10 Superior, 0 = Problematic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student English Language Proficiency (10 = Superior, 0 = Problematic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R² (Adjusted)</td>
<td>0.07</td>
<td>[0.06]</td>
<td>[0.07]</td>
<td>[0.12]</td>
<td>[0.38]</td>
<td>[0.39]</td>
</tr>
<tr>
<td>R² Change</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.05</td>
<td>0.26</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

***coefficients are statistically significant at p < 0.001, **coefficients are statistically significant at p < 0.01, *coefficients are statistically significant at p < 0.05
Factors Related to Science Teacher Beliefs about Approaches to Science Talk

The dialogic and authoritative talk scales measured teachers’ beliefs about the use of student-centered vs. teacher-centered approaches to talk during whole-class discussions as a means of developing students’ understandings of scientific concepts. As reported previously, teacher mean scores were higher for the student-centered, dialogic approach scale (DTAS) than the teacher-centered, authoritative approach scale (ATAS).

Student-centered dialogic talk approach scale.

The same modeling approach described in the previous section was used to investigate the relationship between predictors and the teachers’ dialogic scale scores. Seven models were created which included teacher background factors, perceptions of themselves and perceptions related to students. Of the various models that were tested to determine the possible relationships among the predictors and dialogic talk approach scale (DTAS) scores, only Model 1 was statistically significant with F(1,166) = 5.27, \( p = 0.03 \) (see Table 4.10). This model includes only years of experience as a predictor. With a coefficient of -0.01, teachers in this study with less experience tended to give higher importance to the dialogic talk approach as a means of exploring and developing student understanding of science concepts. The equation for this model is

\[
\hat{Y} = 2.43 - 0.01(experience)
\] (21)

Years of teaching experience however only accounted for 3% of the variation in the teachers’ DTAS score. As more teacher predictors were included in the model, the adjusted \( R^2 \) actually decreased further confirming the fact that the subsequent predictors added into Models 2-5 were nonsignificant. Teachers’ undergraduate degree, attainment
of a graduate degree, and participation in coursework or workshops focusing on science talk was not significantly related to their beliefs about the importance of the dialogic talk approach for student learning. Furthermore, their ratings of content knowledge and knowledge of different discussion strategies were not related to the DTAS scores.

When teacher ratings of their students’ academic ability/content knowledge, motivation/behavior and English language proficiency were included in Model 6, teacher ratings of student academic ability was a statistically significant predictor of DTAS score (see Table 4.9). Model 6 however was not statistically significant with all the other predictors included, $F(10,157) = 1.49, p = 0.15$. In Model 7, nonsignificant teacher predictors were excluded from the model and teacher perceptions of students were retained. This model was statistically significant, $F(4, 170) = 2.59, p = 0.04$ and the coefficient associated with teacher ratings of student academic ability/content knowledge was again statistically significant. This model would suggest that teachers who rated their students higher in academic ability and content knowledge were also more likely to rate the dialogic approach to talk as being more important for student learning of science content. The addition of the student predictors however only increased the variance accounted for by 1%, therefore, although both years of experience and student rating of academic ability were statistically significant, together they only accounted for 4% of the total variance and therefore other factors seem to play a much greater role in teacher beliefs about dialogic talk as an approach to student learning.
Table 4.10. Regression Models predicting Dialogic Talk Approach Scale (DTAS) Scores

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
<td>Coeff. (s.e.)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>2.43(0.06)***</td>
<td>2.42(0.07)***</td>
<td>2.39(0.08)***</td>
<td>2.37(0.09)***</td>
<td>2.03(0.24)***</td>
<td>2.01(0.25)***</td>
<td>2.41(0.14)***</td>
</tr>
<tr>
<td><strong>Teacher Background Predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Experience (Yrs.)</td>
<td>-0.01(0.004)*</td>
<td>0.02(0.07)</td>
<td>-0.10(0.004)*</td>
<td>-0.01(0.004)*</td>
<td>-0.01(0.01)**</td>
<td>-0.01(0.01)**</td>
<td>-0.01(0.004)*</td>
</tr>
<tr>
<td>Undergraduate Degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Biology vs. Physical Science)</td>
<td>0.01(0.07)</td>
<td>0.01(0.07)</td>
<td>0.02(0.07)</td>
<td>0.01(0.07)</td>
<td>0.002(0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate Degree</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Biology vs. Non-Science)</td>
<td>0.08(0.17)</td>
<td>0.08(0.17)</td>
<td>0.09(0.17)</td>
<td>0.07(0.17)</td>
<td>0.09(0.17)</td>
<td>0.09(0.17)</td>
<td></td>
</tr>
<tr>
<td>Graduate Degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(1 = graduate degree, 0 = none)</td>
<td>0.06(0.07)</td>
<td>0.06(0.07)</td>
<td>0.05(0.07)</td>
<td>0.05(0.07)</td>
<td>0.05(0.07)</td>
<td>0.05(0.07)</td>
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</tr>
<tr>
<td>Course/Workshop focusing on Science Talk/Discussions</td>
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</tr>
<tr>
<td>(1 = at least one, 0 = none)</td>
<td>0.05(0.07)</td>
<td>0.04(0.07)</td>
<td>0.02(0.07)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Teacher Perceptions of Themselves</strong></td>
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<td></td>
</tr>
<tr>
<td>Teacher Content Knowledge</td>
<td></td>
<td></td>
<td></td>
<td>0.02(0.03)</td>
<td>0.04(0.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10 = Superior, 0 = Problematic)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Knowledge of Different Approaches to Guide Talk</td>
<td></td>
<td></td>
<td></td>
<td>0.02(0.03)</td>
<td>0.01(0.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10 Superior, 0 = Problematic)</td>
<td></td>
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</tr>
<tr>
<td><strong>Teacher Perceptions of Students</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Student Academic Ability/Content Knowledge</td>
<td></td>
<td></td>
<td></td>
<td>0.08(0.04)*</td>
<td>0.07(0.03)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10 Superior, 0 = Problematic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Motivation/Behavior</td>
<td></td>
<td></td>
<td></td>
<td>-0.03(0.02)</td>
<td>-0.18(0.02)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10 = Superior, 0 = Problematic)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student English Language Proficiency</td>
<td></td>
<td></td>
<td></td>
<td>0.04(0.02)</td>
<td>-0.03(0.02)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10 = Superior, 0 = Problematic)</td>
<td></td>
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</tbody>
</table>

R² (Adjusted)  0.03  (0.02)  (0.01)  (0.01)  (0.01)  (0.03)  (0.04)
R² Change       -0.01  -0.01  0   0   0.03  0.01

***coefficients are statistically significant at p < 0.001, **coefficients are statistically significant at p < 0.01, *coefficients are statistically significant at p < 0.05
When the same teacher independent predictors were used to construct the seven regression models predicting teachers’ Authoritative Talk Approach Scale (ATAS) scores, no model accounted for more than 2% of the variance in scores (see Table 4.11). The F-statistic for each model was also insignificant with $p > 0.10$ for all models. Unlike teacher beliefs about dialogic approaches to talk, years of teaching experience did not play a significant role in predicting beliefs about the authoritative approach. Although the coefficient associated with years of experience in these models was the same as those for the DTAS score models, the distribution of Authoritative Talk Scores had a greater range and was less skewed towards the high end of the scale.
**Table 4.11. Regression Models predicting Authoritative Talk Approach Scale (ATAS) Scores.**

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>1.49(0.07)**</td>
<td>1.43(0.08)**</td>
<td>1.45(0.08)**</td>
<td>1.41(0.09)**</td>
<td>1.75(0.26)**</td>
<td>1.80(0.25)**</td>
<td>1.56(0.13)**</td>
</tr>
<tr>
<td><strong>Teacher Background Predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Experience (Yrs.)</td>
<td>-0.01(0.004)</td>
<td>-0.01(0.004)</td>
<td>-0.01(0.004)</td>
<td>-0.01(0.01)</td>
<td>-0.01(0.01)</td>
<td>-0.01(0.01)</td>
<td></td>
</tr>
<tr>
<td>Undergraduate Degree (Biology vs. Physical Science)</td>
<td>0.10(0.07)</td>
<td>0.11(0.07)</td>
<td>0.11(0.07)</td>
<td>0.12(0.07)</td>
<td>0.11(0.07)</td>
<td>0.13(0.07)</td>
<td></td>
</tr>
<tr>
<td>Undergraduate Degree (Biology vs. Non-Science)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate Degree (1 = graduate degree, 0 = none)</td>
<td>-0.03(0.07)</td>
<td>-0.03(0.07)</td>
<td>-0.01(0.08)</td>
<td>-0.01(0.08)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course/Workshop focusing on Science Talk/Discussions (1 = at least one, 0 = none)</td>
<td>0.07(0.07)</td>
<td>0.08(0.07)</td>
<td>0.05(0.07)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Teacher Perceptions of Themselves</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Content Knowledge (10 = Superior, 0 = Problematic)</td>
<td>-0.03(0.04)</td>
<td>-0.01(0.04)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Knowledge of Science Talk Strategies (10 Superior, 0 = Problematic)</td>
<td>-0.02(0.03)</td>
<td>-0.03(0.03)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Teacher Perceptions of Students</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Academic Ability/Content Knowledge (10 Superior, 0 = Problematic)</td>
<td>0.03(0.04)</td>
<td>0.04(0.04)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Motivation/Behavior (10 = Superior, 0 = Problematic)</td>
<td>0.004(0.02)</td>
<td>-0.02(0.02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student English Language Proficiency (10 = Superior, 0 = Problematic)</td>
<td>-0.05(0.02)*</td>
<td>-0.04(0.02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R² (Adjusted)</strong></td>
<td>0.01</td>
<td>(0.02)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.02)</td>
<td>(0.02)</td>
</tr>
<tr>
<td><strong>R² Change</strong></td>
<td>0.01</td>
<td>-0.01</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

***coefficients are statistically significant at p < 0.001, **coefficients are statistically significant at p < 0.01, *coefficients are statistically significant at p < 0.05***
Like the DTAS score models, teachers’ beliefs about the importance of the authoritative approach to whole-class discussions did not depend on the undergraduate degree or participation in coursework/workshops focusing on different approaches to talk. Furthermore, their ratings of content knowledge and knowledge of talk strategies were also unrelated to their ATAS scores. Teachers’ beliefs about the importance of teacher-centered discussions for learning also did not relate to their ratings of their students’ academic ability/content knowledge or motivation/behavior.

Model 6, which represents the inclusion of all predictors, was not statistically significant as a predictor of ATAS scores, $F(10, 157) = 1.39, p = 0.19$, and it only accounted for 2% of the variance in ATAS scores (see Table 4.10). In this model however, teachers with non-science undergraduate degrees were more likely to rate authoritative approaches to talk as being relatively more important for developing student understandings of science. Given that only 7 respondents were non-science undergraduate majors in the total sample this may not be a good representation of this group. Also, once nonsignificant predictors were removed, non-science undergraduate degree was no longer statistically significant as shown in Model 7. The same held true for the student English language proficiency predictor which was also not statistically significant in any model other than Model 6.

Ultimately, given that no model accounted for more than 2% of the variance in Authoritative Talk Approach Scale (ATAS) Scale scores and that no model produced a significant $F$-statistic, beliefs that teachers have about using authoritative approaches to whole-class discussions is independent of the predictors tested. This result is similar to
that reported for the Dialogic Scale scores and therefore teachers’ beliefs about using authoritative approaches for teaching might be dependent on other factors.

Chi-Square Analyses of Factors Influencing Talk during Whole-Class Discussions

Teachers were asked to rate the relative importance of different environmental and personal factors as influences on the frequency and quality of science talk during whole-class discussions in which the purpose was to develop students’ understandings of a scientific concept. The factor categories included (a) expectations of other adults; (b) instructional factors such as curriculum, time and class size; (c) student factors such as motivation, academic ability and English language proficiency; and (d) teacher factors such as content knowledge and knowledge of instructional strategies to support talk. Each factor was analyzed using a Chi-Square Goodness-of-Fit test in order to determine which factors teachers as a group thought were most important in limiting the frequency and quality of science talk. Subsequently, the Chi-Square Test of Independence was used to determine if the responses teachers gave differed relative to teaching experience and school factors such as average school SES, percent White student demographic, and average school score on the state science test.

**Expectations of Other Adults**

Overall, a significantly higher number of teachers reported that expectations of other adults such as administrators, colleagues, and parents minimally influenced the frequency and quality of whole-class discussions that occurs during lessons (see Figures 4.5 and 4.6). For each factor, approximately two-thirds of the teachers responded that these external expectations played no role to somewhat of an important role in their
whole-class discussions. Of all the adults mentioned in the study, more teachers felt that their colleagues had the least influence on the frequency and quality of talk that occurred in their class. There was no significant relationship with teacher experience or school level factors were included in Goodness-of-Fit tests.

**Figure 4.5.** Chi-Square Results for Teacher Beliefs about the Importance of Administrator, Colleague, and Parent Expectations on the Frequency of Science Talk during Whole-Class Discussions.

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$</th>
<th>17.75***</th>
<th>54.95***</th>
<th>19.02***</th>
</tr>
</thead>
<tbody>
<tr>
<td>$df$</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>183</td>
<td>182</td>
<td>183</td>
<td></td>
</tr>
</tbody>
</table>

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$
Teacher beliefs about the importance of other adult expectations on the frequency and quality of whole-class discussions in their class were therefore independent of the experience and school-level predictors like average school SES, school student demographic, and average state science test scores.

**Instructional Factors**

When teachers were asked to comment on the importance of instructional factors like curriculum, time for content coverage, and large class size, over 70% of teachers believed that these factors were very to extremely important in determining both the frequency and quality of whole-class discussion focused on developing student
understanding (see Figures 4.7 and 4.8). Although a significant majority of teachers ranked all three factors as having high importance with regard to whole-class discussions, the highest percentage of teachers (>80%) ranked time for content coverage as highly important. Teacher ratings of these factors were consistent across years of experience, and school-level predictors, suggesting that teachers across the state felt equally that the current curriculum and amount of content that must be taught within the school year restricts the frequency and quality of whole-class discussion that can take place. Furthermore, a significant number of teachers believed that large class size is also a very important limiting factor of whole-class discussion that is intended to develop student understandings. Unfortunately, it is not possible to ascertain what teachers perceive to be a large class size from this study, however teachers did feel that too many students in class interfered with the frequency and quality of whole-class discussions.
Figure 4.7. Chi-Square Results for Teacher Beliefs about the Importance of School Instructional Factors on the Frequency of Science Talk during Whole-Class Discussions.

Figure 4.8. Chi-Square Results for Teacher Beliefs about the Importance of School Instructional Factors on the Quality of Science Talk during Whole-Class Discussions.
Student Factors

When teachers were asked to rank the relative importance of student factors in limiting the frequency and quality of talk that occurred in class, teachers were equally divided in ranking some factors as having low or high importance (see Figures 4.9 and 4.10). While some teachers felt that students’ limited experience with science talk was not important or somewhat important to conducting whole-class discussions that developed student understandings, a similar number responded that it was a very to extremely important factor. The distribution of responses regarding science talk quality was not similar when teacher experience was taken into consideration, however. Cross-tabulation of the data showed that teachers with more than 10 years of experience were more likely to place less importance on student experience with talk on the quality of whole-class discussions than teachers with 10 or less years of experience, \( \chi^2 (df = 2) = 4.77, p = 0.09 \). While 59% of the less experienced teachers responded that student limited experience was very to extremely important for the quality of talk, approximately 40% of teachers with more experience felt the same way. Teacher experience was not associated with teachers’ responses to the other student factors tested. Also, school-level factors did not influence teachers’ responses to this factor.

There was no statistically significant difference in the designation teachers gave to the relative importance of student expectations, student content knowledge, and English language proficiency on the frequency of talk (see Figure 4.9). A significantly greater percentage of teachers (58%) however believed that limited student content knowledge did play a very to extremely important role in the quality of science
discussions with $\chi^2 (df = 1) = 3.98, p = 0.046$. In the case of this factor, it is interesting to note that the results were similar for frequency and quality in terms of percentage, but because of the lower number of teachers who responded to
Figure 4.9. Chi-Square Results for Teacher Beliefs about the Importance of Student Factors on the Frequency of Science Talk during Whole-Class Discussions (A).

---

***p < 0.001, **p < 0.01, *p < 0.05

Figure 4.10. Chi-Square Results for Teacher Beliefs about the Importance of Student Factors on the Quality of Science Talk during Whole-Class Discussions (A).
this section of the survey, a statistically significant difference was attained. School-level factors did not influence teacher responses to this factor.

Teacher ratings of importance diverged more strongly when considering student motivation, student behavior and academic ability as factors (see Figures 4.11 and 4.12). Limited student motivation and student behavioral issues were seen as highly important factors in determining both the frequency and quality of whole-class discussions by over 70% of the respondents. This response rate was not influenced by teacher experience or school-level factors and therefore was consistent across the group of teachers.

![Chi-Square Results for Teacher Beliefs about the Importance of Student Factors on the Frequency of Science Talk during Whole-Class Discussions (B).](image)

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$**

*Figure 4.11. Chi-Square Results for Teacher Beliefs about the Importance of Student Factors on the Frequency of Science Talk during Whole-Class Discussions (B).*
***p < 0.001, **p < 0.01, *p < 0.05

Figure 4.12. Chi-Square Results for Teacher Beliefs about the Importance of Student Factors on the Quality of Science Talk during Whole-Class Discussions (B).
Student academic ability was reported as having little to no importance in the frequency and quality of science talk by a significantly greater percentage of teachers (60%). Although the responses teachers gave did not vary depending on experience or school-level factors with respect to frequency, teacher responses about the importance of student academic ability with respect to the quality of whole-class discussions were significantly different when considering school-level factors (see Figure 4.13). Teachers in schools with the highest number of students participating in the Free/Reduced lunch program were more likely to rate student academic ability as very to extremely important in limiting the quality of science whole-class discussions. The reverse was true when considering those schools with the lowest percentage of students on Free/Reduced lunch, $\chi^2(df = 1) = 8.64, p = 0.003$. Similar results were found when cross-tabulations were performed using school White demographic and average state test scores. Given that all three school-level predictors used in this study were highly correlated, this was expected.

Although the high school teachers, as a group, were more likely to state that student academic ability was minimally important for the quality of discussions, this was not true of teachers from high schools with a higher percentage of underprivileged students. In this case, teachers from low SES schools were more likely to respond that limited student academic ability was a highly important factor in limiting the quality of talk that takes place during lessons. Both groups of teachers rated students’ content knowledge in a similar way. Teachers in high SES schools were more likely to give high importance to limitations in students’ content knowledge and suggest that limited student
academic ability was minimally important. While limited content knowledge can be perceived as a deficit that can be overcome with instruction, academic ability is typically viewed as an intrinsic characteristic or capability of students which influences what they are able to learn and do. The disproportionate number of teachers in low-SES schools who rated limited academic ability as highly important for the quality of discussions may play a role in the expectations teachers have for talk as a strategy for student learning.

Figure 4.13. Teacher Beliefs about the Importance of Student Academic Ability in the Quality of Science Talk as a function of Average School Socioeconomic Status.
Personal Factors

Lastly, teachers were asked to rate the relative importance of personal factors on the frequency and quality of the whole-class discussions in their class. Overall significantly more teachers rated their experience with student science talk, confidence with the content being taught and knowledge of instructional strategies used to develop students’ understandings of scientific concepts as highly important in limiting the frequency of science talk during whole-class discussions (see Figure 4.14). Both content knowledge and knowledge of instructional strategies for talk were seen by more teachers as also playing a role in limiting the quality of talk that took place during whole-class discussions (see Figure 4.15) as well. Of all three personal factors however, teacher knowledge of instructional strategies to support science talk was given the very to extremely important rating by the highest percentage of teachers in limiting both the frequency and quality of science talk. Over 63% of teachers in this survey felt that knowledge of instructional strategies was a factor that could impact science talk during whole-class discussions. Years of teaching experience and school-level factors did not significantly effect the distribution of these responses as determined by Chi-Square Tests of Independence.
Figure 4.14. Chi-Square Results for Teacher Beliefs about the Importance of Personal Factors on the Frequency of Science Talk during Whole-Class Discussions.

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$</th>
<th>df</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience Guiding Talk</td>
<td>9.29**</td>
<td>1</td>
<td>181</td>
</tr>
<tr>
<td>Confidence with Content</td>
<td>19.78***</td>
<td>1</td>
<td>182</td>
</tr>
<tr>
<td>Knowledge of Instructional Strategies</td>
<td>30.09***</td>
<td>1</td>
<td>182</td>
</tr>
</tbody>
</table>

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$
Figure 4.15. Chi-Square Results for Teacher Beliefs about the Importance of Personal Factors on the Quality of Science Talk during Whole-Class Discussions.

***p < 0.001, **p < 0.01, *p < 0.05
Summary

As a result of this study, it is apparent that whole-class discussions are frequently utilized as an instructional approach by secondary science teachers. Also, it seems that teachers find dialogic forms of talk to be more important for learning than authoritative forms. The investigation of factors relating to teachers’ beliefs as measured by four different scales shows that teachers’ beliefs about efficacy and the importance of different approaches to talk are not related to the same factors (see Table 4.12). Theoretically, it was proposed that both contextual and personal factors might play a role in teachers’ beliefs about the use of whole-class discussions as an instructional strategy. Interestingly, many beliefs seemed to be consistent across schools. Only teachers’ scores on the outcome expectancy scale were significantly different between schools but unfortunately, the analysis was not able to decipher what school-level factors might explain the differences in teachers’ responses. In terms of teachers’ beliefs about self-efficacy, teachers’ participation in courses and professional development focused on exploring strategies for guiding talk during whole-class discussions was positively related to their sense of self-efficacy using this approach to teaching. This is further supported by the Chi-Square test results that showed teachers rank knowledge of instructional strategies as highly important in the quality and frequency of talk that occurs in their classes.
Table 4.12. Summary of factors relating to teachers’ efficacy and approach beliefs.

<table>
<thead>
<tr>
<th>Related Factors</th>
<th>Outcome Expectancy</th>
<th>Self-Efficacy</th>
<th>Dialogic Approach</th>
<th>Authoritative Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>School-level factors exist, but were not determined</td>
<td>Participation in coursework/PD related to higher efficacy scores</td>
<td>More years of teaching experience related to slight decrease in importance rating</td>
<td>No statistically significant relationship to tested factors was apparent.</td>
<td></td>
</tr>
</tbody>
</table>

While teachers’ efficacy scores were related to some of the predictors that were included in the statistical models, both contextual and personal predictors did not seem to be significantly related to the importance teachers placed on authoritative approaches to talk. It may be that other experiences, like how the teachers themselves were taught, may be more related to their beliefs about which approaches to talk are most effective.

Teachers’ beliefs about the importance of using a dialogic approach seemed to decrease with more years of teaching experience, but the relationship explained only a small portion of the variance in scores, therefore again it seems that there are other factors that more greatly influence teachers’ beliefs about using a student-centered approach to talk.

In terms of factors influencing the quality and frequency of student-centered whole-class discussions, contextual factors had a variable influence. While the expectations of other adults did not seem to be important for the majority of teachers, instructional factors such as curriculum, class size and time to teach content were viewed as highly important factors by the majority of teachers. The most important student-related factors were student motivation and behavior. While the teachers’ overall responses suggested that students’ academic abilities were less important than content
knowledge in playing role during whole-class discussions, teachers from lower SES schools were more likely to state that limited student academic ability was a factor in limiting the quality of discussion in their class. Personal factors were also reported however as playing a significant role in the quality and frequency of student-centered whole-class discussions. In this case, most teachers reported that knowledge of strategies to guide this type of talk was highly important.

Overall, the results from the Rhode Island teacher survey suggest that while teachers rate dialogic approaches to talk as being more important during instruction than authoritative approaches, many teachers are not engaging in development that elucidates strategies that can be used to shift talk away from predominantly teacher-centered interactions. Besides this, teachers cited both curricular and student factors as key elements limiting the extent to which they can engage in more dialogic interactions. While curricular demands and content coverage have been discussed in many other studies as factors that influence teachers’ approaches to talk, little has been presented about the students’ role in the discussion. The case study in the next chapter therefore attempts to better understand the importance of student factors in maintaining or shifting talk during whole-class discussions.
CHAPTER FIVE: ANALYSES OF TEACHER AND STUDENT BELIEFS ABOUT SCIENCE TALK DURING WHOLE-CLASS DISCUSSIONS – A CASE STUDY

While the previous chapter examined relationships in secondary science teachers’ beliefs about whole-class discussions, this chapter investigates these factors more closely as they play out in the classroom. Specifically, this chapter focuses on three of the research questions: 1) How do teachers perceive their role and the students’ role in authoritative and dialogic whole-class discussions? 2) What is the relationship between a teacher’s perceived approach to dialogic science talk and actual instruction during whole-class discussions? and 3) What factors are associated with students’ beliefs about participating in science talk and the teacher’s role during whole-class discussions?

This case study focuses on one high school chemistry teacher and three of her classes. First, in order to contextualize the findings, I provide descriptions of the teacher, her students, the school in which they interact and the goals of each lesson. Then I present four themes that emerged from the analysis of the multiple data sources. The first theme focuses on the interactions that occurred during the whole-class discussions and the teacher’s beliefs about her role in those discussions. The second theme will show how variations in the teachers approach to talk related to students’ contributions to the discussion. The third theme focuses on students’ understandings and preferences for dialogic and authoritative approaches to talk. Finally, the last theme suggests that student perspectives about the social and epistemological framing of whole-class discussions impact the dynamics that exist when students and teachers interact during lessons.
Description of Participants and Context

The Teacher

Ms. Romac is a 50-year-old chemistry teacher with eight years of teaching experience. She came into teaching as a second career after having worked in several positions that made use of her Bachelor’s degree in Chemistry. Before teaching, she worked as a chemist and quality control specialist in some chemical companies and she also worked as a laboratory manager in a university research facility. After staying at home to raise her children, she entered a teacher certification program and became a teacher because she “wanted to put the two things that I really enjoy doing together: science and working with teenagers.”

A passionate science educator, Ms. Romac believes that “everybody in this world needs to be scientifically literate” which she defines as being “able to think about the world and science and ask the questions that help them make sense of what appears in the paper, what appears in their lives”. She states that in order to do this, students have to “be able to think about it and search out the answers to questions in a methodical way that will allow them to make good decisions.” She believes that background knowledge is required to do this. She wants all of her students, “even the kids in my general class” to be “skeptical thinkers”. In the end, she hoped that her students “will be able to go out and choose careers and not be afraid of them just because chemistry happens to be a part of the curriculum.”

When talking about her three classes, Ms. Romac made distinctions among the class levels. She felt that “being fair doesn’t mean treating everybody the same.” Having
a child with special needs herself, she recognized “that everyone comes with different tools, a different background and a different make up in terms of how they learn and how much they can learn at one time and how prepared they are in terms of abstract reasoning versus non-abstract reasoning.” While she viewed her “honors kids” as “future doctors, our future researchers and our future scientists” and hoped that her college preparatory students “might choose a science career of some kind”, she vocalized the real challenges that exist in teaching the general-level class which included students with severe learning disabilities and behavior disorders. She holds high expectations for all her students, but felt that students in her general-level class excelled more at understanding the practical, while her other students could more easily handle abstract and mathematical thinking.

In terms of whole-class discussion, Ms. Romac estimated that she spent about 50% of class time engaged in this instructional approach. Her score on the Science Teacher Efficacy Beliefs Scale (STEBS) was approximately one point below the mean score of the statewide survey discussed in the previous chapter. Her score on the Science Teacher Outcome Expectancy Scale was one point above the statewide mean. These scores suggest that although she felt less efficacious compared to the average teacher in the state, she had a greater expectancy that whole-class discussions bring about student learning. While Ms. Romac’s score of 2.14 on the Dialogic Talk Approach Scale was similar to that of the mean statewide score (2.31) suggesting that student-centered approaches were very important during whole-class discussions, her score on the Authoritative Talk Approach Scale of 2.00 was slightly higher than the mean score (1.43) of the teachers who responded to the statewide survey suggesting that she placed slightly
more importance on teacher-centered approaches during whole-class discussions than the average high school teacher in the state. Lastly, like 40% of the teachers in the state, Ms. Romac reported never having taken a course or workshop focused on strategies for guiding science talk during whole-class discussions.

The Students

The students participating in this study came from three distinct classes: Chemistry II, College Preparatory Grade 10 Chemistry, and General Grade 10 Chemistry. Chemistry II was an honors-level elective taken by interested students in their junior or senior year after already completing Grade 10 Chemistry. On the other hand, enrollment in the Grade 10 chemistry classes was a graduation requirement for all students. According to the school’s Program of Studies (2011), course placement into different levels of Grade 10 chemistry was determined by a student’s teacher “based on a combination of factors including the student’s ability, achievement, motivation, and program direction. Guidance counselors, department heads, students, and parents also play a key role in this pupil placement process” (p.5). For all practical purposes, students are placed in a level by teacher recommendation, however teachers’ recommendations can be challenged by other stakeholders in the child’s education.

The description of the Chemistry II course in the Program of Studies stated that the course could be taken as an elective after completion of Grade 10 Chemistry as part of the a local college Early Enrollment Program. The goal of the course was “to have students experience a typical freshman college level chemistry course… The emphasis of
the course is on understanding versus memorization, problem-solving, verification strategies… and the development of mathematical models” (Program of Studies, 2011, p. 34). Of the 21 students in the class, all but one student participated in the study.

Compared to the other classes, the participants from Chemistry II had a much lower percentage of females, but had the greatest ethnic diversity. Furthermore, a higher percentage of the students in this class reported that they had immediate family members involved in a science-related career (45%). Lastly 90% of the students in this class had at least one parent with a post-secondary degree (see Table 5.1).

**Table 5.1. Descriptive Statistics of Student Characteristics by Class.**

<table>
<thead>
<tr>
<th></th>
<th>Chemistry II</th>
<th>C. P. Chemistry</th>
<th>General Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Participants</td>
<td>20</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>25%</td>
<td>57%</td>
<td>55%</td>
</tr>
<tr>
<td>Males</td>
<td>75%</td>
<td>43%</td>
<td>45%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European/White</td>
<td>60%</td>
<td>100%</td>
<td>91%</td>
</tr>
<tr>
<td>African American</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0%</td>
<td>0%</td>
<td>9%</td>
</tr>
<tr>
<td>Other</td>
<td>35%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Member of Immediate Family Involved in Science Related Career</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>55%</td>
<td>86%</td>
<td>91%</td>
</tr>
<tr>
<td>Yes</td>
<td>45%</td>
<td>14%</td>
<td>9%</td>
</tr>
<tr>
<td>Highest Level of Education - Parents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School Diploma</td>
<td>10%</td>
<td>28%</td>
<td>82%</td>
</tr>
<tr>
<td>Associate or Bachelor Degree</td>
<td>60%</td>
<td>36%</td>
<td>18%</td>
</tr>
<tr>
<td>Masters Degree or Doctorate</td>
<td>30%</td>
<td>36%</td>
<td>0%</td>
</tr>
</tbody>
</table>
College preparatory (C.P.) Grade 10 Chemistry was “designed for the college-bound student. Students in this course are prepared to interpret everyday events in terms of chemical concepts and principles…gain experience and practice in mathematical interpretation chemical principles as well as the interpretation of empirical and graphical data” (Program of Studies, 2011, p. 31). There were 27 students in this class and 14 participated in the study. In this class, each gender was similarly represented. All of the participants in this class identified themselves as European/White. Only two students (14%) reported that they had an immediate family member involved in a science-related career. Lastly, 72% of the students participating in the study from this class reported that at least one parent had a post-secondary degree (see Table 5.1).

General Grade 10 Chemistry was “designed to provide an alternative approach to chemistry, particular [sic] for students with difficulties in mathematics. The chemistry course will focus more on organic chemistry, biochemistry, and industrial and environmental chemistry using real life problems from the community…The mathematics in this course will be introduced as it is needed” (Program of Studies, 2011, p. 31). There were 19 students in this class and 11 participated in the study. Like C. P. Chemistry, gender representation was approximately equal. One student identified himself as Hispanic while all others identified themselves as European/White. Only one student (9%) reported that they had an immediate family member involved in a science-related career. Lastly, two students (18%) reported that at least one parent had attained a post-secondary degree (see Table 5.1).

The School
The teacher and students participating in this study were members of a high school community in a suburban region of Rhode Island. The total enrollment was approximately 1050 students with 93% percent identifying themselves as White. This is a higher percentage than the 68% state comprehensive high school average. The high school also had a lower percentage of students participating in the free/reduced lunch program (26%) compared to the state average (44%). In terms of science performance, 30.7% of the 11th grade students were deemed proficient in science as measured by the statewide assessment, while the mean proficiency score statewide was 26%. The descriptive statistics of this school are similar to those of many other suburban high schools in the state.

The Lessons

The focus of this case study revolved around Ms. Romac’s and her students’ beliefs about talk during whole-class discussions in general and as they related to nine chemistry lessons: three lessons for each chemistry class. Each lesson was approximately one hour long and is considered a class period. Ms. Romac chose these lessons to be videotaped because she considered them to be good examples of the whole-class discussions that took place in her class. Table 5.2 describes the goals Ms. Romac set for each class. While none of the lessons in the Chemistry II classes coincided to the lessons in the other classes, Lesson 1 and 2 in the C. P. and General classes dealt with primarily the same chemistry concepts and goals. Chemistry II Lesson 3 was distinctly different from the others because groups of students led the whole-class discussion. General
Chemistry Lesson 3 was also different than the others because students participated in a Socratic seminar based on the Apollo 13 movie.
<table>
<thead>
<tr>
<th>Lesson</th>
<th>Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemistry II</strong></td>
<td></td>
</tr>
<tr>
<td>Lesson 1</td>
<td>To refine students’ understanding of ionization energy as they relate to periodic trends and electron configurations.</td>
</tr>
<tr>
<td>Lesson 2</td>
<td>To connect (compare/contrast) the concepts of ionic bonding with covalent bonding including energy concepts.</td>
</tr>
<tr>
<td>Lesson 3</td>
<td>To have students deepen their understanding of molecular geometry by having groups lead discussions using a set of slides provided by a molecular modeling program.</td>
</tr>
<tr>
<td><strong>C. P. Chemistry</strong></td>
<td></td>
</tr>
<tr>
<td>Lesson 1</td>
<td>To review concepts of energy transformations and then relate those concepts to the flame test lab students had performed in a previous class. Particular attention was placed on helping students develop the conclusion section of their lab reports.</td>
</tr>
<tr>
<td>Lesson 2</td>
<td>To specify the characteristics of chemical reactions by having students observe a demonstration at the front of the class and teach students how to balance chemical equations.</td>
</tr>
<tr>
<td>Lesson 3</td>
<td>To teach students the significance and application of the mole unit in chemistry by presenting different examples and then relating the mole units to the periodic table.</td>
</tr>
<tr>
<td><strong>General Chemistry</strong></td>
<td></td>
</tr>
<tr>
<td>Lesson 1</td>
<td>To review concepts of energy transformations and then relate those concepts to the flame test lab students had performed in a previous class. Particular attention was placed on helping students develop the conclusion section of their lab reports.</td>
</tr>
<tr>
<td>Lesson 2</td>
<td>To define the components of a chemical equation and teach students how to balance them.</td>
</tr>
<tr>
<td>Lesson 3</td>
<td>To have students participate in a Socratic seminar focused on the problem-solving process. The main question was, “How did the individuals working on the Apollo 13 project problem solve to get the astronauts back home?” Prior to this lesson, students watched the Apollo 13 movie in class.</td>
</tr>
</tbody>
</table>
Classroom Practice and Beliefs around Science Discussions

In this section I describe four themes that emerged from my analysis of the multiple data sources utilized in the case study. Specifically, I began by analyzing and characterizing the talk that occurred in the nine lessons focusing my attention on the types of questions that were being asked by the teacher and the students. I then used the teacher and student interviews and student surveys to identify possible relationships that existed between the type of talk that was apparent during lessons and the beliefs that the teacher and her students had about the role of whole-class discussions as an approach to learning. Subsequently, I investigated the possible relationship between the teacher’s approach to questioning during lessons and the extent of reasoning that students contributed to the discussions by performing multiple regression using the incidence of key reasoning indicator words in student responses as the outcome variable and different types of teacher questions as the predictor variable. Lastly, I did a comparative analysis of students’ responses to the survey and interviews in order to explore common beliefs among students about whole-discussions and differential beliefs among students of different groups. In the end, four dominant themes emerged from my analyses which are presented on Table 5.3.
Table 5.3. Four Themes from Case Study Analysis

<table>
<thead>
<tr>
<th>Theme 1</th>
<th>The teacher’s authoritative approach in whole-class discussions corresponds with her beliefs and her students’ beliefs about her role.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theme 2</td>
<td>Variation in the teacher’s approach was related to differences in students’ reasoned responses, but the teacher had difficulty shifting away from the authoritative approach.</td>
</tr>
<tr>
<td>Theme 3</td>
<td>Students believed that both dialogic and authoritative features of talk were important in developing students’ understandings of a scientific concept.</td>
</tr>
<tr>
<td>Theme 4</td>
<td>Students’ social framing of their role (e.g. passive versus active) was related to the level of their chemistry class and the frequency that they contributed in class discussions.</td>
</tr>
</tbody>
</table>

Theme 1: The Teacher’s Authoritative Approach in Whole-Class Discussions

Corresponds with Her Beliefs and Her Students’ beliefs about the Teacher’s Role.

Although Ms. Romac had expressed clear distinctions among the students in her leveled classes, there were many similar aspects of the whole-class discussions that occurred in the lessons across all classes. For the most part, the discussions were teacher-driven, meaning that Ms. Romac asked most of the questions and followed up students’ answers with an elaboration of their significance. The excerpt in Table 5.4 shows an example of the exchanges that occurred in Lesson 2 of the C. P. Chemistry class focusing on chemical reactions. In this particular instance, Ms. Romac is discussing the chemical reaction related to the demonstration she has placed in the front of the class. The positioning of Ms. Romac as the center of the discussion is typical of the transcripts throughout most lessons.
Table 5.4. Excerpt of Discussion during Lesson 2 of the C.P. Chemistry Class.

<table>
<thead>
<tr>
<th>Excerpt</th>
<th>Question Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Ms. Romac: And I added it to what?</td>
<td>Closed</td>
</tr>
<tr>
<td>2  Jack: CuCl₂.</td>
<td></td>
</tr>
<tr>
<td>3  Jenny: Copper Chloride.</td>
<td></td>
</tr>
<tr>
<td>4  Ms. Romac: CuCl₂. Copper Chloride. Now what you see happening and the reason that I hesitated when you said rust is because this isn’t rust.</td>
<td></td>
</tr>
<tr>
<td>5  Deidre: Iron oxide is rust.</td>
<td></td>
</tr>
<tr>
<td>6  Ms. Romac: Iron oxide is rust. You’re absolutely right. I can actually feel the heat given off by this now. It’s kind of cool. So what product should I write over here given that everything in the reactants is going to end up in the products? What over there could possibly be that color?</td>
<td>Closed</td>
</tr>
<tr>
<td>7  Sam: Copper.</td>
<td></td>
</tr>
<tr>
<td>8  Mandy: Cu.</td>
<td></td>
</tr>
<tr>
<td>9  Ms. Romac: The copper. Yeah. Okay. So what we’re seeing is that copper coming out of solution. That copper ion is gaining a couple of electrons and it’s going back to copper metal. It’s an oxidation-reduction reaction. I don’t know if we’re going to get to that this year. Now the aluminum. We’re not going to be able to see what happens to the aluminum. If you look at this one that has been sitting for a couple of days, look at how fragile it is. There’s a hole in the bottom of it.</td>
<td></td>
</tr>
<tr>
<td>10 Ms. Romac: There’s a hole in the bottom of it. What’s happening is the aluminum is actually going into solution because it’s giving up electrons to the copper and forming aluminum chloride. Now notice that I changed the number of chlorines that I was using. Why? Why did I put three chloride ions with aluminum and two with the copper? Why did I do that?</td>
<td>Closed</td>
</tr>
<tr>
<td>11 Cindy: Because you</td>
<td>Closed</td>
</tr>
<tr>
<td>12 Ms. Romac: Well you’re experts at nomenclature. Deidre.</td>
<td></td>
</tr>
<tr>
<td>13 Deidre: So aluminum has a 3⁺ charge and copper has a 2⁺ charge depending on which one you use.</td>
<td></td>
</tr>
<tr>
<td>14 Ms. Romac: Yeah. Exactly. So I’m going to write my formula for aluminum chloride just like you’ve been doing nomenclature.</td>
<td></td>
</tr>
<tr>
<td>15 John: What is it?</td>
<td></td>
</tr>
<tr>
<td>16 Ms. Romac: There’s a hole in the bottom of it. What’s happening is the aluminum is actually going into solution because it’s giving up electrons to the copper and forming aluminum chloride. Now notice that I changed the number of chlorines that I was using. Why? Why did I put three chloride ions with aluminum and two with the copper? Why did I do that?</td>
<td>Closed</td>
</tr>
<tr>
<td>17 Cindy: Because you</td>
<td>Closed</td>
</tr>
<tr>
<td>18 Ms. Romac: Well you’re experts at nomenclature. Deidre.</td>
<td></td>
</tr>
<tr>
<td>19 Deidre: So aluminum has a 3⁺ charge and copper has a 2⁺ charge depending on which one you use.</td>
<td></td>
</tr>
<tr>
<td>20 Ms. Romac: Yeah. Exactly. So I’m going to write my formula for aluminum chloride just like you’ve been doing nomenclature.</td>
<td></td>
</tr>
</tbody>
</table>
Throughout all the lessons, with the exception of the Chemistry II Lesson 3 class where student groups taught the class, students’ contributions to the discussion were typically limited to phrases or single sentences in response to Ms. Romac’s questions or when students asked questions themselves. If we only consider content-related questions and disregard the managerial questions that Ms. Romac asked, the majority of Ms. Romac’s questions were typically closed, either as a form of initiating a student response or as a means of pumping for more information (see Table 5.5). Ms. Romac was much more likely to initiate a student response with a closed question and in most cases was more likely to follow up a student response in the C. P. and General chemistry courses with closed pumping questions than to ask students to openly elaborate on their answers to clarify the reasoning behind their thinking or to toss the answer back to the class for peer commentary.
Table 5.5. Incidence of Teacher Questions Associated with the Lessons.

<table>
<thead>
<tr>
<th></th>
<th>Chemistry II</th>
<th>C. P. Chemistry</th>
<th>Gen. Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td>L3</td>
</tr>
<tr>
<td>Rhetorical Questions</td>
<td>9</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>Closed Questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiating</td>
<td>14</td>
<td>46</td>
<td>21</td>
</tr>
<tr>
<td>Pumping</td>
<td>8</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>Open Questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiating</td>
<td>10</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Elaboration</td>
<td>1</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Reflective Toss</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Total Questions/Lesson</td>
<td>47</td>
<td>10</td>
<td>64</td>
</tr>
<tr>
<td>Total Questions/Class</td>
<td>219</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the total number of questions Ms. Romac asked in each lesson varied overall, she asked fewer questions of her honors students than she did of the other classes. When comparing the incidence of the different question types over the three classes, Ms. Romac asked a higher percentage of closed questions than rhetorical and open questions (see Figure 5.1). While the percentage of different question types asked were very similar for the C. P. and General classes, Ms. Romac asked a higher proportion of rhetorical and open questions to her Chemistry II class. The rhetorical questions were usually associated with extended teacher explanations of phenomena while open questions explored student thinking about phenomena and were not associated with definitive right or wrong answers.
Figure 5.1. Percentage of Teacher Question Types Associated with Each Class Level.

After watching excerpts of the lessons, Ms. Romac’s comments about the discussions provided some explanation for why the lessons were so teacher driven. In describing the talk in Lesson 2 of all three classes, she stated that she was “providing the forward movement for the discussions…I had a place where I wanted to go with each of those classes. I knew what I wanted them to think about at a particular time.” She also noticed that she was “calling on the same people because I’m trying to move the subject forward.” She defined one of her roles in whole-class discussion as overseer. While she would “sit back and see what happens” if the discussion did not head in the direction she wanted, her role was to “ask a question that will maybe steer it in a certain direction.” Closed questions are useful for this purpose of maintaining direction because they are limited in types of responses that students can give.

Ms. Romac took very seriously her role as content specialist in the room. She believed her role was to “make it concrete for them, and explain things in a way that will
help them relate it to knowledge they already have, provide the link for them so that when they’re sitting there in class and they’re thinking, oh I remember this…then they’re starting to put it in those file drawers in their brain”. She justified this way of thinking by explaining that the chemistry concepts her students had to learn were new and not easy for many students so it was important that she helped them in this way. She referred several times to the idea that she was also modeling the thinking that goes along with bringing concepts together. In referring to lesson 2 of her Chemistry II class, she noticed that students were not connecting to prior knowledge so “I was trying to lead them to that understanding”. Her role was consistent for all three tracks. It was her expectations for the amount of detail students should know that differed.

Calling on students to participate in whole-class discussions was a way to have students “listening to each other…not just me” while also providing a way to “find out what they knew.” She found that whole-class discussions could be difficult however because while there are “those kids who come prepared and have put the background in to understand what question I’m asking, there are also “those kids that don’t come prepared and don’t know what’s going on.” In referring to her approach to discussions, Ms. Romac stated that “I try to use questions that are going to cause them to use the knowledge that I want them to have gained, maybe in the last homework or the last chapter that we did and tie it together.” This focus on knowledge acquisition supports the use of closed questions to help identify which students need extra support in learning the background information she thinks is important.
Ms. Romac’s beliefs about her role aligned well with the expectations students expressed about the purpose of talk and the teacher’s role in that talk both in the survey and during interviews. In the open response section of the survey, 86% of the students referred to the teacher as a guide or leader whose role it was to keep the discussion focused, on task or moving in a certain direction. This idea was echoed during the interviews when some students at all levels stated that Ms. Romac’s role was to point students in the right direction. Furthermore, some students at all levels mentioned that one of the main purposes of whole-class discussions was to give the teacher an idea of what the students knew and her role was to check on student knowledge and understanding. These ideas were consistent with the student responses to the Likert Scale Items where 93% of student respondents rated it very to extremely important that the “teacher evaluates and provides feedback immediately after a student contribution” and 87% of them answered that it was also very to extremely important that the “teacher reshapes and elaborates on student responses.” To some degree then, the teacher-driven discussions that were apparent in most of the lessons was in line with both the teacher’s and the students’ expectations for important elements of whole-class interactions for learning.

That being said, Ms. Romac did verbalize a sense of dissatisfaction with the extent to which she spoke during the discussions when she was asked to comment on what trends she was noticing throughout the lessons. She thought that “one of the hardest things to do is to stay on top of the wave of discussion… and sort of guide it. I don’t want to be the only one talking, although I seem to be doing a lot of the talking which is
really annoying.” She felt that her preparation for using whole-class discussion during instruction was based in her experiences as a student in “college-level, upper-level classes.” When referencing the education courses in her teacher preparation program she said “there was no discussion about things other than the very practical like don’t turn your back on the classroom… they never talked about how do you have a discussion in class.” Furthermore, in regard to current professional development trends, she felt that “everything is about supporting reading, writing and math in the classroom” because of the focus on improving state assessment scores. She said that “we’re almost discouraged from doing whole-class discussion because…hands-on learning is more valuable.” Overall, Ms. Romac felt that she was not properly prepared to take on different approaches to talk and that her evaluators did not place a high value on this mode of instruction.

**Theme 2: Variation in the Teacher’s Approach was Related to Differences in Students’ Reasoned Responses, But the Teacher had Difficulty Shifting Away from the Authoritative Approach**

Although most lessons were predominantly teacher-centered, variations in the approach that the teacher took either towards the entire lesson or questioning within the lessons themselves were related to the contributions of reasoned responses students used within the discussion. Specifically, the two lessons that exhibited a higher degree of student reasoned responses were also those that diverged from the typical teacher-led discussion. In one of the lessons, the teacher designed the class such that the students taught the class. In the other lesson, the teacher utilized a Socratic seminar. As shown
in Table 5.6, students reasoning words were most evident during Lesson 3 for Chemistry II (Student Taught) and Lesson 3 of the General Chemistry class (Socratic Seminar). For both of these lessons, the teacher had decided to approach the whole-class discussion differently because she wanted to make the discussion more dialogic and student-centered given the predominantly authoritative approach she had noticed in video clips from the previous lessons. While these two lessons represented the greatest difference in approach to whole-class discussions by Ms. Romac, more subtle variations in her approach to questioning were also apparent throughout all the lessons and therefore possible relationships were also investigated between her use of questioning and the extent of student reasoning in the discussion.

**Student Taught Lesson.** The highest number of reasoning words occurred in the Chemistry II class where various groups of students taught the class different aspects of molecular geometry. In this lesson (L3), students contributed 171 reasoning indicator words to the discussion which is over four times more than the average number of contributions from the other classes.
Table 5.6. Incidence of Reasoning Indicator Words in Each Lesson

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>But</td>
<td>4</td>
<td>3</td>
<td>19</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Because</td>
<td>10</td>
<td>20</td>
<td>34</td>
<td>18</td>
<td>6</td>
<td>4</td>
<td>11</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>I think</td>
<td>6</td>
<td>0</td>
<td>14</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>If</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Why</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Which</td>
<td>0</td>
<td>2</td>
<td>18</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>What</td>
<td>5</td>
<td>3</td>
<td>20</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Agree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>So</td>
<td>8</td>
<td>18</td>
<td>51</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Unless</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Since</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Indicator Words</td>
<td>42</td>
<td>50</td>
<td>171</td>
<td>44</td>
<td>20</td>
<td>21</td>
<td>47</td>
<td>10</td>
<td>72</td>
</tr>
</tbody>
</table>

Ms. Romac stated that she was pleased overall with this lesson because the students in some ways took on her role. In fact, most of the indicator words came while student groups explained the topic they were assigned. It was also necessary to use teacher question codes to analyze some of the students’ questions because unlike in the other lessons, 28% of the questions that the students asked their peers were closed questions: 9 initiating questions and 2 pumping questions. In the other lessons, when students did infrequently choose to directly question a peer, it was typically in order to ask for a clarification of what had been said or to ask for the student to repeat their utterance. In this lesson however, those students who took on the teacher’s role also shifted in the types of questions they believed were acceptable to ask of fellow students, thereby asking closed, authoritative questions. This would reinforce the students’ belief that one of the teacher’s roles is to gauge or assess students’ understanding of the topic being discussed with the use of questions.
Furthermore, although the teacher’s intention was to shift the focus away from her, Ms. Romac was still very involved in guiding the discussion. While her students asked a total of 39 questions including teacher-type closed and open questions, Ms. Romac asked 64 total questions. She also entered the discussion frequently to address what she considered was misinformation. When asked about the activity, one student who doesn’t tend to speak much in the class stated that if she were the teacher “I would have rather let students finish and then gone back the next day and say this is where I figured out that you guys have problems.” However, this student was also of the opinion that truly open whole-class discussions should only occur at the end of a unit when students know what they are talking about. She likes “people to know what they’re talking about when they’re teaching it.” Another student in the class who speaks frequently thought that “it’s the teacher’s role to step in and straighten things out because you don’t want to mislead the students.” The latter student was probably more representative of the students who took the survey given that 93% rated teacher evaluation and immediate feedback as very to extremely important during whole-class discussions. So while students did not seem to mind that their peers were teaching the class, they felt that the teacher still had the role of overseeing the discussion and interjecting when information might be misleading or out of line with the scientific story.

The excerpt in Table 5.7 is an example of how Ms. Romac “stepped in” during the Lesson 3 discussion which was meant to be student-led. In this exchange, Ms. Romac began by asking the class why the molecule being discussed by the group in the front of the class would “not be trigonal planar?”
Table 5.7. Excerpt of Discussion during Lesson 3 of the Chemistry II Class.

<table>
<thead>
<tr>
<th>Excerpt</th>
<th>Question Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivan: Because of the two electrons on Boron. So it would</td>
<td></td>
</tr>
<tr>
<td>cause it to be bent because the chlorine electrons have</td>
<td></td>
</tr>
<tr>
<td>to, are going to be repelled from the Boron’s electrons.</td>
<td></td>
</tr>
<tr>
<td>Ms. R: Is it going to be bent?</td>
<td>Reflective Toss</td>
</tr>
<tr>
<td>Ivan: Well it will be.</td>
<td></td>
</tr>
<tr>
<td>Ms. R: What’s that going to be? What’s that shape going to be?</td>
<td>Closed/Closed</td>
</tr>
<tr>
<td>Ivan: Tetrahedral something.</td>
<td></td>
</tr>
<tr>
<td>Ms. R: Yeah. What’s the word? You all used that word when</td>
<td>Closed</td>
</tr>
<tr>
<td>you were introducing the shape on the right there. I</td>
<td></td>
</tr>
<tr>
<td>don’t want to say words that are going to…What’s the</td>
<td>Closed</td>
</tr>
<tr>
<td>shape Mitch?</td>
<td></td>
</tr>
<tr>
<td>Mitch: I think that is supposed to be a trigonal planar.</td>
<td>Reflective Toss</td>
</tr>
<tr>
<td>Ms. R: Is it trigonal planar?</td>
<td></td>
</tr>
<tr>
<td>Mitch: Yeah.</td>
<td></td>
</tr>
<tr>
<td>Ivan: No. Trigonal planar is just when it’s like that.</td>
<td>Closed</td>
</tr>
<tr>
<td>Ms. R: Yeah. What’s the difference between trigonal planar</td>
<td></td>
</tr>
<tr>
<td>and this shape that I’m looking for?</td>
<td></td>
</tr>
<tr>
<td>Jen: inaudible</td>
<td>Closed</td>
</tr>
<tr>
<td>Ms. R: It’s those lone pairs like you were talking about. So</td>
<td></td>
</tr>
<tr>
<td>what’s the name of that shape?</td>
<td></td>
</tr>
<tr>
<td>Tim: Tetrahedral pyramidal.</td>
<td></td>
</tr>
<tr>
<td>Ms. R: Yeah. It’s tetrahedral pyramidal.</td>
<td></td>
</tr>
</tbody>
</table>

After considering Mitch’s response later, Ms. Romac acknowledged that Mitch was actually correct in his categorization of the molecule as trigonal planar, but at the time she had not realized it. Had the students been encouraged to debate the issue directly with one another, this difference in student understanding might have been an opportunity for students to interact dynamically and dialogically, but students in this case directed their responses towards the teacher and Ms. Romac led the discussion towards the shape she wanted the students to recognize, tetrahedral pyramidal. When I asked Mitch why he did not pursue his answer further when throughout the lessons he always seemed confident expressing his ideas, he said “I could have explained why it was
trigonal planar except it gets to the point where they go off in their own direction and you
can’t really say anything.” After observing the video clips for this lesson, Ms. Romac
commented that she was pleased about the discussion and that students were able to
clarify the topic while getting other students involved. She stated “So I was happy. Even
though I messed up on the trigonal planar.”

When asked what she might do differently, Ms. Romac focused on what the
students could do to better prepare for their presentation. She suggested that maybe she
would give “them time with me to develop questions.” When asked about her own
preparation, she said “I didn’t know what to do to prepare. I have taken classes on this
molecular modeling stuff and I understood how the models worked and I understood how
the students could interact with them… I was trying something new.” In this case, Ms.
Romac related preparation for the discussion in terms of the content and the manipulation
of the software. She did not seem to reflect on how she would maintain her external role
during the discussion. After viewing the clips, she acknowledged that “I wanted to be in
the background. I was a little too much in it, but that’s okay. I feel like I wasn’t
overwhelming” when compared to the General class’ Socratic seminar.

_Socratic Seminar Lesson._ During the lesson three (L3) Socratic seminar
mentioned by Ms. Romac, students also contributed more reasoning words to the
discussion than the other two lessons (see Table 5.6), but the increase was less than twice
what had occurred in lesson 1. Ms. Romac structured this discussion as a Socratic
seminar focusing on the question “How did the individuals working on the Apollo 13
project problem solve to get the astronauts back home?” The change in discussion
structure and Ms. Romac’s use of more open questions during this lesson (see Table 5.5) seemed to influence the type of contributions that students were making to the discussion. Ultimately however, Ms. Romac noted that “it ended up being me leading the discussion which I was disappointed. I was hoping that they would talk to each other and I guess I didn’t have a good feel for where the class was in terms of trust with each other.” Furthermore, she attributed the lack of active participation by students to the fact that “they just don’t remember what happened in the movie. And so having a discussion on it is kind of pointless because they just don’t remember.” In this case as well, Ms. Romac focused on the students’ lack of preparation or unwillingness to participate in the discussion and did not reference her role in maintaining the authoritative structure evident in the lesson.

The fact that the main question framing the Socratic seminar was a closed one asking for students to name specific examples of the problem solving process in the movie limited the extent to which students could interact dialogically. The discussion began with the question “How did they figure out what to do first?” The following interactions consisted mostly of the teacher asking questions that helped student reconstruct what had happened in the movie (see Table 5.8).
Table 5.8. Excerpt of Discussion during Lesson 3 of the General Chemistry Class.

<table>
<thead>
<tr>
<th>Excerpt</th>
<th>Question Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ms. R: What do you remember about what happened after?</td>
<td>Open</td>
</tr>
<tr>
<td>2 Tim: They tried to make a filter for the air.</td>
<td></td>
</tr>
<tr>
<td>3 Ms. R: Okay. So what was another thing they had to do? Jim, what</td>
<td>Closed</td>
</tr>
<tr>
<td>4 do you think?</td>
<td>Managerial</td>
</tr>
<tr>
<td>5 Jim: Everything has been brought up.</td>
<td></td>
</tr>
<tr>
<td>6 Ms. R: What?</td>
<td>Repeat</td>
</tr>
<tr>
<td>7 Jim: Everything has been brought up.</td>
<td></td>
</tr>
<tr>
<td>8 Ms. R: Inaudible.</td>
<td></td>
</tr>
<tr>
<td>9 Sally: They had to go through steps.</td>
<td></td>
</tr>
<tr>
<td>10 Ms. R.: They had to go through steps. Why did you say that?</td>
<td>Elaboration</td>
</tr>
<tr>
<td>11 Sally: To fix the filter.</td>
<td></td>
</tr>
<tr>
<td>12 Ms. R: To fix their filter? Alright, everybody take the packet that I</td>
<td>Rhetorical</td>
</tr>
<tr>
<td>gave you and turn to the page that ahs the suggestions. It’s</td>
<td></td>
</tr>
<tr>
<td>in that box. I think it’s the second page. I’m going to</td>
<td></td>
</tr>
<tr>
<td>reshape my questions in a way that maybe helps us have a</td>
<td></td>
</tr>
<tr>
<td>more open discussion. And I want to put a little more</td>
<td></td>
</tr>
<tr>
<td>opinion in now. I want you to look at this list and let’s take</td>
<td></td>
</tr>
<tr>
<td>Sally’s suggestion of the filter. Alright? Making the filter.</td>
<td></td>
</tr>
<tr>
<td>19 That was several steps down the line after the decisions</td>
<td></td>
</tr>
<tr>
<td>20 making process happened. First of all let’s try to remember.</td>
<td></td>
</tr>
<tr>
<td>21 Why did they have to make a filter?</td>
<td>Closed</td>
</tr>
</tbody>
</table>

Few examples existed of students talking directly to each other. Throughout the lesson the conversation would bounce from teacher to student then back to the teacher. At one point students began raising their hands to speak and Ms. Romac responded by saying “I’m not going to do hands. Can you speak to me without raising hands?” So although the students were sitting in a circle and the structure had been presented as a Socratic seminar, the types of questions being asked influenced their framing of the lesson thereby influencing them to interact within a more authoritative structure.

According to one of the students I interviewed, this lesson was the first time the General Chemistry class had engaged in a Socratic seminar. Being a senior in a class of
predominantly sophomores, she attributed the limited nature of student participation to a lack of maturity and student preparation. She said “I think there’s just a problem with that, the level of maturity. I don’t think they’re ready to talk about their opinion like that yet. Also a lot of people missed the movie so they really didn’t know what they were talking about.” She believed however that “everyone was respectful and waited their turn…so it went well in that sense.” Another student in the class felt that the discussion lacked excitement, “something to make it more spicy and interesting.” This student had watched the movie three times previous to the lesson, but he wasn’t “as into it as the teacher would probably like.” In the end, neither the teacher nor the students attributed the authoritative nature of the Socratic seminar to the closed focus question and the overall purpose of the discussion. Both the teacher and the students cited deficiencies in the students as a possible reason for the disappointing Socratic seminar.

Cross Lesson Analysis. While it is apparent from the analysis of these two lessons that the increased incidence of students’ use of reasoning indicator words did not necessarily mean that the discussion was dialogic in its purest sense, it did suggest that students were contributing more of the reasoning and explanations to the discussion instead of having the explanations coming only from the teacher. Given that some of the dialogic talk features include students initiating new ideas into the discussion, clarifying their responses and providing reasoning when they contribute to discussions, an analysis of the indicator words does give some indication of the extent to which the discussion was open to student thinking. Looking more deliberately at the possible relationship between Ms. Romac’s use of open questions and her students’ use of reasoning indicator
words, it seems that the increased use of teacher open questions during the discussion was associated with a higher use of indicator words on the part of the students (see Figure 5.2).

Figure 5.2. Relationship between Ms. Romac’s Use of Open Questions and the Students’ Use of Reasoning Indicator Words.
When considering the eight lessons in which Ms. Romac led the discussions, her use of open questions was significantly related to students’ use of reasoning indicator words with $R^2 = 0.77$, $F(1,6) = 20.17$, $p = 0.004$. The use of open questions therefore accounted for 77% of variation in students’ expressions of reasoned responses. So while Ms. Romac’s approach was authoritative overall, she did vary the extent to which she encouraged students to participate in the discussion. Interestingly, although the percentage of open questions she asked of her honors Chemistry II class was slightly higher than the other classes, the overall pattern of questioning was similar among all classes (see Figure 5.1) suggesting that she did not necessarily believe that her honors students were more capable of learning from dialogic approaches to talk compared to her other students.

Ms. Romac however did not mention her approach to questioning as an element she would change to improve the discussions. After viewing a video clip from Lesson 2 of the honors Chemistry II class, she suggested that “if it were a better discussion, I would have had more people involved…I’m calling on the same people probably because I’m trying to move forward.” But this response focuses on the number of students participating, not on the type of responses students gave. In the end, although Ms. Romac was able to bring about more reasoned student contributions with open questions, it does not seem like that it was the result of a conscious choice. Although she did say that she made an effort during the observations to give me “what a discussion was”, she was referring to the length of the discussion and wanting to provide as much data for me as possible, not her overall approach to questioning. Before starting the study however, I
did explain to Ms. Romac that I was interested in how teachers’ used talk to understand student thinking; basically, the reasoning behind why students gave the answers they did. Although this discussion between us may have led Ms. Romac to ask more open questions during some lessons when I was there, overall her tendency continued to focus on closed questions. While this analysis suggests that Ms. Romac possesses the ability to make whole-class discussions more student-centered in part with the questions she asks, not having had an opportunity to understand the use of different questioning strategies and approaches within whole-class discussions limits the extent to which she can reflect more extensively on the exchanges that are occurring during lessons and what can be done to shift them.

Theme 3: Students believed that both dialogic and authoritative features of talk were important in developing students’ understandings of a scientific concept.

Recognizing the fact that students play an equally important role in the dynamics of whole-class discussions, the third theme shifts to focus on the students’ beliefs about approaches to talk. All forty-five students who participated in this study were asked to complete a survey consisting of three parts: the Science Talk Approach Likert Scale Items, five open response questions, and a section including background questions. The Likert Scale items were the same as those included in the teacher’s survey discussed in Chapter 4. Factor analysis of the teachers’ responses to items associated with Dialogic and Authoritative talk separated into the two theorized factors thereby producing the Dialogic Talk Approach Scale (DTAS) and the Authoritative Talk Approach Scale (ATAS). Principal components analysis of the student responses produced different
results. Final loadings for the students’ responses to the same items resulted in four factors with Eigenvalues greater than one. Eigenvalues showed that the first factor accounted for 22% of the variance in student responses, the second factor 20% of the variance, the third factor 11% of the variance and the fourth factor 8%. The emergence of four factors instead of two suggests that students think about the features of talk differently in some ways than teachers do. Although five of the six dialogic feature items loaded together, one dialogic feature loaded with theoretically authoritative features. Furthermore, the authoritative features which loaded together for teachers, separated into three distinct factors for students (see Table 5.9).
Table 5.9. Factor Loadings Based on Principal Components Analysis with Varimax Rotation for 13 Items from the Talk Approach Scale (N=45)

<table>
<thead>
<tr>
<th>Factor Label</th>
<th>Item</th>
<th>Item Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialogic Interactions</td>
<td>Teacher asks students to clarify or elaborate on their responses.</td>
<td>.60</td>
</tr>
<tr>
<td></td>
<td>Teacher and students build on each other’s ideas</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>Students contribute personal points of view</td>
<td>.68</td>
</tr>
<tr>
<td></td>
<td>Teacher is open to different points of view</td>
<td>.64</td>
</tr>
<tr>
<td></td>
<td>Students initiate new ideas into the discussion.</td>
<td>.70</td>
</tr>
<tr>
<td></td>
<td>Students talk directly to each other</td>
<td>.49</td>
</tr>
<tr>
<td>Science Story</td>
<td>Students provide reasoning when they contribute to discussions</td>
<td>.60</td>
</tr>
<tr>
<td></td>
<td>Teacher focuses on the scientific explanation for phenomena.</td>
<td>.81</td>
</tr>
<tr>
<td></td>
<td>Teacher reshapes and elaborates on students responses</td>
<td>.70</td>
</tr>
<tr>
<td></td>
<td>Teacher questions students about content facts and vocabulary.</td>
<td>.45</td>
</tr>
<tr>
<td>Class Management</td>
<td>Teacher rigidly guides the direction of the discussion</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>Students contribute to the discussion only when called upon by a teacher</td>
<td>.83</td>
</tr>
<tr>
<td>Assessment Role</td>
<td>Teacher evaluates and provides feedback immediately after student contributions</td>
<td>.73</td>
</tr>
</tbody>
</table>

Cronbach’s Alpha .75 .65 .56

Factor Loadings <0.4 are suppressed
The first factor, which contained most of the dialogic feature items, was labeled dialogic interactions. All items seemed to revolve around the open expression of ideas among the students and teacher in the class. The second factor was labeled science story because all items seemed to focus on particularly shaping the scientific explanations in the discussions. The third factor was named class management because these two items dealt more with the teacher’s role in guiding and managing the discussion including directing when students are allowed to talk. The last factor, which had only one strongly loading item, was labeled assessment because it related to the teacher’s role as evaluator and feedback provider for student contributions. Cronbach’s alpha was calculated to examine the internal consistency for each of the factors which included more than one item. The resulting alphas were moderate for the first two scales: 0.75 and 0.65 respectively. While the third scale consisting of only two items was weak with Cronbach’s alpha = 0.56. The last scale only consisted of one item so Cronbach’s alpha was not calculated.

Because students did not seem to have distinct and unified conceptualizations of dialogic and authoritative approaches to talk, scale scores were not calculated as they were for teachers in the previous chapter. Instead, I explored which features most students believed were highly important for whole-class discussions in which the purpose is to help develop students’ understandings of a scientific concept. While all features were considered to be highly important for whole-class discussions by over 50% of the students, five features were considered to be very or extremely important to over 80% of
the student participants. The items are listed in Table 5.10 ordered by the percentage of students who considered the feature highly important.

*Table 5.10. Five Features of Whole-Class Discussion Considered Highly Important By Over 80% of Student Survey Participants (N=45)*

<table>
<thead>
<tr>
<th>Feature Categorization</th>
<th>Item</th>
<th>Number of Students (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialogic</td>
<td>Teacher is open to different points of view.</td>
<td>44 (98%)</td>
</tr>
<tr>
<td>Authoritative</td>
<td>Teacher evaluates and provides feedback immediately after student contributions.</td>
<td>42 (93%)</td>
</tr>
<tr>
<td>Dialogic</td>
<td>Teacher and students build on each other’s ideas.</td>
<td>41 (91%)</td>
</tr>
<tr>
<td>Authoritative</td>
<td>Teacher reshapes and elaborates on students’ responses.</td>
<td>39 (87%)</td>
</tr>
<tr>
<td>Dialogic</td>
<td>Students provide reasoning when they contribute to discussions.</td>
<td>38 (84%)</td>
</tr>
</tbody>
</table>

The beliefs about the high importance of these features in whole-class discussions were consistent for all class levels. Chi-square tests including crosstabulations considering the possible influence of class on results suggested that there were no significant differences among classes for these items for all $\chi^2 (2, N = 45), p > 0.2$.

Interestingly, the students who responded to this survey believed that both dialogic and authoritative features of talk were very to extremely important in developing students’ understandings of a scientific concept. While all students except one believed that it was highly important that teachers were open to a variety of students’ points of view, all but three believed that it was also highly important that teachers evaluate and provide feedback on what students were saying. It would seem, therefore, that although
students would like the freedom to voice their perspectives during discussions, they want the teacher to evaluate, provide feedback, reshape and elaborate on what students say. This was evident in the types of questions that students asked during the lessons I observed (see Table 5.11). Considering the high number of closed questions asked by the teacher which solicited fact-based responses by the students, looking at the questions students asked gives some idea of the extent to which students brought in new perspectives or alternative points of view.

Table 5.11. Summary of Student Questions Associated with the Lessons.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Chemistry II</th>
<th>C. P. Chemistry</th>
<th>Gen. Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td>L3</td>
</tr>
<tr>
<td>Clarification</td>
<td>16</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Extension</td>
<td>6</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Question-Answer</td>
<td>0</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Total Questions/Lesson</td>
<td>25</td>
<td>22</td>
<td>12</td>
</tr>
</tbody>
</table>

| Total Questions/Class | 59 | 55 | 52 |

In all lessons, students asked much fewer questions than the teacher did. Students asked more clarification questions in the lessons than any other type of question. Extension questions that brought in a new perspective or idea into the discussion were seen less frequently and depended greatly on the lesson, but did not seem to relate to the level of the class. Also present in each lesson were question-answers in which students responded to a closed question with an answer in the form of a question.
Responses students provided to the open survey questions and during interviews suggest that although students want the teacher to be open to different points of view, they themselves are more focused on providing the correct answer to discussions versus contributing alternative points for discussion. For example, most students responded on the survey that they are least likely to contribute to the discussion when they felt that they would be wrong (33%), they thought their contribution was irrelevant or unimportant (40%), or their contribution would interrupt the discussion (13%). Alternatively, they would say something in class if they knew the right answer (49%) or they needed clarification (33%).

During the interviews, most students described science as a discipline of rules and facts or what one honors student called “generally accepted answers.” For him, the purpose of whole-class discussions “should be to clarify what’s known” adding that “if you want to look into other possibilities, that’s fine, but you should know the basics before you start doing that.” These ideas were echoed by another honors student when she compared science class to her other classes. She thought that in science “you can’t attach interpretations because you don’t have the background to know it, so you need those structured classes that take care of all those gaps.” In her case, she believed that open discussions that allowed for dialogic student participation could only happen “after the chapter was completed…until the information is covered, I don’t think discussions are warranted because you don’t know enough to have an informed discussion.”

This epistemological framing centering the class discussion on understanding what is known in science may help to explain how students want apparently contradictory
dialogic and authoritative features of talk to exist simultaneously. In talking about student contributions during interviews, many students mentioned that listening to other students’ perspectives and point of views were helpful for learning because other students could sometimes convey the information differently or better than the teacher thereby helping to fill in their gaps in knowledge. Overall, the points of view that student referred to did not seem like perspectives that were up for debate, rather other ways of talking about a common scientific point of view. As one C. P. student put it, “for certain things, there’s not more than one way of looking at it.” Although students wanted to be able to express their understandings of topics, in the end, they acknowledged that in class there was a scientific way of understanding the world and they expected that the teacher would monitor and shape that understanding. In this respect, one general-level student expressed her satisfaction with Ms. Romac’s approach to talk saying “Chem is kind of like facts. So it’s more of getting lectured when we’re learning than actually talking back and forth, but she’s really good at teaching.” She thought the biggest benefit to having students participate in the discussion was that “when a student does it, and they understand it and they explain it, it’s kind of more my level.”

Theme 4: Students’ social framing of their role (e.g. passive versus active) was related to the level of their chemistry class and the frequency that they contributed in class discussions.

While it appeared that there were common student beliefs about expectations for classroom talk during whole-class discussions and the teacher’s role in that talk, distinctions among groups of students were evident when I considered their beliefs about
the student’s role or social framing in whole-class discussions. Social framing refers to the expectations that students have about how individuals in the class will interact with each other and the teacher. In this respect, differences were found not only when classes were compared, but also when interviews of students who were frequent contributors to talk were compared with the infrequent contributors.

Class Comparisons

While all of Ms. Romac’s students but one wanted the teacher to be open to students’ points of view, there was a significant difference between the Chemistry II class and the other classes as to how students should be contributing to that discussion. Most of Ms. Romac honors Chemistry II students believed that it was minimally important that “students contribute to discussion only when called on by the teacher.” On the other hand, only half of the students surveyed in the C. P. and General classes shared this belief (see Table 5.12). A chi-square test of the student responses to this items which included class in crosstabulations showed a statistically significant difference existed in the Chemistry II students’ responses and those of the students in the other classes with $\chi^2 (2, N = 45) = 6.69, p = 0.04$. A greater percentage of students in the non-honors classes believed therefore that for productive whole-class discussions, a student should wait to be called upon before contributing.

Table 5.12. Incidence of Students’ Ratings Relative to the Importance of Contributing Personal Only When Called on by the Teacher.

<table>
<thead>
<tr>
<th></th>
<th>Minimal Importance</th>
<th>High Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry II</td>
<td>17 (85%)</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>C. P. Chemistry</td>
<td>7 (50%)</td>
<td>7 (50%)</td>
</tr>
<tr>
<td>General Chemistry</td>
<td>5 (45%)</td>
<td>6 (55%)</td>
</tr>
</tbody>
</table>
When I asked a General Chemistry student about his response to the survey which suggested it was very important for students to only contribute when called on by the teacher, he said that he had put that down “because that’s what I was taught.” This student had been selected for the interview because he frequently contributed to class discussions and felt comfortable doing so. He would usually raise his hand and wait to be called on by the teacher however before contributing to the discussion. He thought that waiting for the teacher to call on him or waiting his turn was the “polite” thing to do. He didn’t want to interrupt someone when he or she was speaking. In addition to this student, five students stated in the open response question of the survey that they were least likely to contribute if the teacher did not call on them or if the teacher did not allow student contributions. Only one of the students was from the honors class, while the other four came from two C. P. and two General Chemistry (2) students. It is important to note however that although students in the honors class thought it was minimally important to only contribute when the teacher called on them, they did usually wait to be called on by the teacher when contributing to the discussion and frequently raised their hand before speaking.

In terms of the student’s role in the discussion, there was a distinct difference between the General Chemistry students’ responses and the other students. While students in the Chemistry II and C. P. Chemistry classes used more active and collaborative language when describing their role, the majority of students in the general class stated that their main role was to listen and learn. No students in the other classes used the word “listen” in the open response section to describe their role in whole-class
discussions. While one student in the honors class wrote that his role was to “pay
attention,” most student role descriptions in both the Chemistry II and C. P. Chemistry
classes were active like contribute ideas, participate, ask questions, and help others (see
Table 5.13). In this table, only those role descriptions suggested by more than one
student in the class appear.

Table 5.13. Students’ Beliefs about their Role in Whole-Class Discussion.

<table>
<thead>
<tr>
<th>Role Description</th>
<th>Chemistry II (number of students)</th>
<th>C. P. Chemistry (number of students)</th>
<th>General Chemistry (number of students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contribute ideas (8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expand/Elaborate/Evaluate (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask Questions (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answer Questions (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learn from others/Help each other learn (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participate (2)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Contribute ideas/opinions (6)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Participate (5)</td>
<td></td>
<td></td>
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<tr>
<td>Learn from conversation (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask questions (2)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Learn from other/Help each other learn (3)</td>
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</tbody>
</table>

Equally noteworthy is the fact that all the answers from the General Chemistry
students participating in this study focused the student’s role internally with no student
mentioning social interactions with other students as part of their role in discussions.
Even during the interviews with General Chemistry students, only one of six students
stated that sharing ideas was part of her role, while four of the students took on a more
passive approach. One student stated that his role was “to listen” and “take what she [the
teacher] says into me.” In the other classes, students included many more active
descriptions of their role with three students in each non-general class stating that their
role in whole-class discussions was to help others learn or to learn from others. This
isolated social framing of the general-level students was also evident in the reasons they have for whole-class discussions. None of the students in the General Chemistry class stated that learning or collaborating with others was a reason for whole-class discussions, while four students in each of the other classes did.

The most active student roles were found in the Chemistry II students’ responses to the survey. While contributing ideas was the most common reference, some students also mentioned that they should be expanding or elaborating on what was being said during the discussion as well as evaluating what was being said. In the lesson observations, there was evidence that students in this class did refer back to what other students said either to ask a question or elaborate on the response. Socially, however, these references to other student responses were most often mediated by the teacher and directed towards the teacher. While there is one instance when a student directly asked another “Do you mean like the second one? Can you repeat your question?” such an interaction was atypical except in the case of Lesson 3 when the students were teaching the class.

Frequent Talkers vs. Infrequent Talkers

Students’ social framing of whole-class discussions and their perceptions of the interactions they witnessed had distinct elements when the interviews and surveys of the frequent contributors to discussions in the observed lessons were compared with infrequent contributors regardless of class level. Student beliefs about the impact of their contributions on others and their own learning as well as their personalities seemed to relate to their willingness to participate in the discussions. Two themes accounting for
their approach to talk emerged from the comparative analysis of their responses: (a) Approach to Talk in Relation to Other’s Learning and (b) Social Comfort. Although not all students in each talking category (frequent vs. infrequent) included references to every theme, there were similar responses in each group that stood out for each theme.

Approach to Talk in Relation to Learning. Some students explained their tendencies towards discussions in terms of students’ learning. Several frequent talkers referred to their contributions to discussions as being beneficial to their own learning as well as the learning of other students, while students who talked infrequently suggested that their contributions were unnecessary or would interfere with the learning of others (see Table 5.14). For several frequent talkers, the responsibility for learning in class was not isolated only to themselves, but included helping other students learn the subject as well. Students who were selected because of their tendency not to speak as much in class felt that either it was not their place to help other students understand or that their questions and contributions would be an interruption rather than a benefit to their peers.
### Table 5.14. Differential Beliefs about Students’ Approaches to Whole-Class Discussions by Frequent and Infrequent Talkers in Relation to Others’ Learning.

<table>
<thead>
<tr>
<th>Frequent Talkers</th>
<th>Infrequent Talkers</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I guess personally if I have a questions, I’d rather ask it in class and see because I feel like other people probably have the same questions so to ask in class is easier for everyone else too.”</td>
<td>“I wasn’t asking questions to clarify because …I understand how to do the problems. I feel like if I were to answer all the questions, I’d be taking away from students as they try to learn”</td>
</tr>
<tr>
<td>“You don’t feel like you’re interrupting as much because it is for everyone.”</td>
<td>“It’s not really my place to tell other people how to do this, because I’m not the teacher.”</td>
</tr>
<tr>
<td>- Chem. II Female 07</td>
<td>- General Chem. Male 17</td>
</tr>
<tr>
<td>“If I’ve read it somewhere and it’s generally accepted to be certain, then I feel like I’m not just going to let people be confused about it.”</td>
<td>“I don’t want to stop the class or I don’t want to interrupt a class or stop everybody else from learning.”</td>
</tr>
<tr>
<td>- Chem. II Male 13</td>
<td>- C. P. Chem. Male 19</td>
</tr>
<tr>
<td>“If you’re understanding, you’re going to try to help others and learn more yourself”</td>
<td>“I don’t want to interrupt anyone”</td>
</tr>
<tr>
<td>- C. P. Chem. Male 22</td>
<td>- General Chem. Female 01</td>
</tr>
<tr>
<td>By talking “we could have other people know how to help them [students who don’t understand] out.”</td>
<td></td>
</tr>
<tr>
<td>– General Chem. 08</td>
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</tbody>
</table>

Students’ differential positioning of themselves within the discussion may be due to variations in their perceptions of what is going on. While frequent talkers were more likely to be satisfied with the type of class discussions that took place and characterize them as being open to student ideas, infrequent talkers were more likely to describe the classes as being closed. The male C. P. student who did not want to interrupt the class (see Table 5.14) also described discussion as “not really a class discussion…It’s like one student or two students just answering questions.” Similar descriptions came from the interviews with two Chemistry II students who infrequently contributed to discussions. One student described his class’ discussion as being “mainly one student and the teacher...
talking amongst each other…It was like a lecture from someone other than the teacher.” Describing a different lesson, a female Chemistry II student said, “it’s basically just the teacher talking through someone else.” In these cases, the students socially framed the discussion as relatively closed to participation for those students who were not interested in an interactive lecture. By viewing the lessons in this way, infrequent talkers were more likely to perceive the discussion as a means by which students could acquire and demonstrate knowledge of the subject rather than a place to introduce new ideas or ask questions. Since these students were less likely to suggest that their contributions would help others learn as well, this may explain why they considered participating in the discussion as more of an intrusion than an asset to the discussion.

*Social Comfort.* Students’ responses to the interviews suggested that the extent to which students feel comfortable interacting with others in the class also plays a role in their approach to participating. Comfort was mentioned not only in terms of familiarity with the students in the class, but also in terms of how students described their own personalities (see Table 5.15).
Table 5.15. Comfort and Contributing to Whole-Class Discussions

<table>
<thead>
<tr>
<th>Frequent Talkers</th>
<th>Infrequent Talkers</th>
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</thead>
<tbody>
<tr>
<td>“I don’t really care what others think.”</td>
<td>“It’s just more of a shy thing.”</td>
</tr>
<tr>
<td>- General Chem. Female 03</td>
<td>– General Chem. Female 02</td>
</tr>
<tr>
<td>“I’m not really self-conscious.”</td>
<td>“I learn better by listening…I’m kind of shy”</td>
</tr>
<tr>
<td>- Chem. II Male 17</td>
<td>- General Chem. Female 06</td>
</tr>
<tr>
<td>“In this class, I know everyone, so I’m comfortable asking a question.”</td>
<td>“I contributed more in Chem. I, I feel because I better knew the people…When I don’t know the people as well in the class, I have a harder time contributing.”</td>
</tr>
<tr>
<td>- General Chem. Male 18</td>
<td>- Chem. II, Female 03</td>
</tr>
<tr>
<td>“I barely talk in certain classes, but in my chem. class, we have a good group of kids and I know most of them.”</td>
<td></td>
</tr>
<tr>
<td>- C. P. Chem. Female 03</td>
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As a community of learners, whole-class discussions take place among individuals with different personal characteristics and historical stories with relation to their peers. The female general chemistry student who said that she did not care what others in the class thought of her was a senior in a class with mostly sophomores. She believed that a student’s readiness to contribute to whole-class discussions was partly a function of a student’s “level of maturity.” Because she was a senior she didn’t “really care because they’re all younger than me so I’ll do whatever I want” in terms of contributing to discussions.

Students who frequently talked in class tended to feel less self-conscious about their participation. Although some students referred to their nature or personality as a reason for their willingness to participate, it is noteworthy that some students acknowledged that their approach to talk in class was related to their familiarity with the
other students in the class. While one frequent talker in C. P. chemistry stated that she barely talks in certain classes, an infrequent talker in Chemistry II acknowledged that she participated more frequently in the prerequisite chemistry class. Both commented that when they are familiar with the students in the class, they are more likely to participate. Given that many students in this study felt a great need to contribute only correct answers because of how they might be perceived by their peers, familiarity with the other students in the class and a sense of community may be important for certain students to feel safe contributing to discussions.

Summary

While Ms. Romac placed high importance on both authoritative and dialogic approaches to talk, her lessons were predominantly authoritative in nature. Her approach aligned with the beliefs she had and her students had about her role as the source of the scientific perspective in whole-class discussions. Variations in Ms. Romac’s approach both subtle, as seen at the questioning level, and more obvious, as seen in the change in discussion structure, impacted the extent to which students contributed reasoned responses to the discussions. A strong positive relationship was apparent between the teacher’s use of open questions and the incidence of reasoned responses by students. In the end however, Ms. Romac was more likely to identify deficiencies in student preparation as a major limiting factor in the quality of the whole-class discussion rather than to refer to specific elements of her own approach to the discussions. While she sought to increase student participation in the discussions, she did not seem to know how this could be accomplished. Furthermore, her focus seemed to be on the number of times
students participated in the discussion as opposed to the types of responses the students were contributing.

In regard to students, their epistemological framing of the whole-class discussions was consistent among the three classes. It also aligned well with the teacher’s beliefs that she was presenting the scientific point of view in a way that students could learn and understand. The students’ social framing of the discussions varied however depending on the class they were or their level of participation in class discussions. General level students tended to take on a more passive approach to whole-class discussions than other students seeing their role as receivers of the information that the teacher was presenting, while students in the other classes used more active language to describe their role in the discussion. Differences were also apparent in how comfortable students were in relation to their peers in the class. Those students who felt less self-conscious and were more familiar with the students in the class, seemed to contribute more freely to the discussion.
CHAPTER SIX: CONCLUSIONS AND IMPLICATIONS

The goal of this dissertation was to investigate which factors are related to teachers’ and students’ beliefs about engaging in science talk during whole class discussions. The recently released *Frameworks for K-12 Science Education* (National Research Council [NRC], 2011) makes frequent references to discussion and discourse as important components of science instruction. Even though other reform documents have stressed the importance of more student-centered dialogue during science lessons, little change in teachers’ approaches to discussion has been documented in science education research. It is valuable therefore to understand what factors may be preventing the shift in science teaching so that we can go beyond the “rhetoric of reform” (Russell & Martin, 2007).

Teachers seem to have difficulty shifting from traditional forms of discussions even when using curriculum materials designed to support more student-centered talk (Alozie et al., 2010; McNeill & Pimentel, 2011; Puntambekar et al., 2007). Exploring the role of teachers’ and students’ beliefs and perceptions in maintaining teacher-centered discussions may provide insight into why reform-based instructional approaches to talk have not become the norm. This dissertation therefore sought to answer the research question: *What are the factors that influence teachers’ and students’ beliefs about engaging in science talk during whole-class discussions?* In order to achieve a more comprehensive understanding of this topic, I investigated the question at both the macro level, using a statewide survey of high school teachers, and the micro level, engaging in a case study of a chemistry teacher and her students.
This dissertation provides significant insights into factors that may be contributing to the continued predominance of authoritative interactions during science instruction even after repeated attempts have been made by reformers to shift talk towards more dialogic, student-centered interactions. First, although teachers and students felt that whole-class discussions were important aspects of instruction, they conceptualized dialogic and authoritative talk differently. Secondly, while teachers thought that taking on a dialogic approach during lessons was more important for student learning than the authoritative approach, teachers’ self-efficacy beliefs related to guiding talk were associated with personal factors like pedagogical and content knowledge. Furthermore, contextual factors for both teachers and students played a role in the dynamics that occurred during whole-class discussions. While current research says little about how students frame whole-class science discussions both epistemologically and socially, this dissertation provides insight into the students’ perspectives on engaging in whole-class discussions, acknowledging that they are integral participants in the talk that occurs during whole-class discussions at the secondary level.

This chapter will situate the major findings of this study within the broader body of science education research and practice. Subsequently, limitations of this study will be presented. Finally, implications will then be discussed which not only suggest topics for teacher preparation and professional development, but also address the often neglected shift at the student level that must be considered in order for science discussions in secondary classrooms to change.
Conclusions

Teachers and Students Conceptualize Approaches to Talk Differently

Whole-class discussion is the most common form of science instruction (Alexander, 2006; Mercer & Littleton, 2007). Two-thirds of teachers in this study reported using whole-class discussions at least 50% of the time. Although previous case studies have investigated teachers’ approaches to whole-class discussions with regards to dialogic and authoritative elements as they play out in the classroom (Alozie et al., 2010; Jiménez-Aleixandre et al. 2000, Scott et al., 2006), the teachers’ responses to the survey in this dissertation demonstrate that teachers have distinct conceptions of dialogic and authoritative approaches to whole-class discussions in that two distinct factors resulted from the approach to talk scale. Furthermore, they believe that dialogic forms of discourse are more important overall for student learning than the authoritative approach.

In regards to shifting class discussions towards more reform-based talk, this is beneficial because Johnson (2009) demonstrates that teachers’ beliefs play a role in whether or not teachers change their practices as a result of professional development. Teachers’ beliefs however do not necessarily predict the approach they take during instruction. The relationship between beliefs and practices is influenced by contextual factors (Jones & Carter, 2007; Mansour, 2009), therefore, this study does not give evidence that the teachers who scored higher on the Dialogic Talk Scale are more likely to use dialogic approaches in their class discussions. It does show however that teachers find value in approaches that are being suggested by current science reform documents, so the main
challenge in shifting approaches to discussion may not be convincing teachers that it is worthwhile, but addressing other factors that are impeding the change.

Students who participated in the case study did not have such a cohesive understanding of dialogic and authoritative approaches to talk, however. As a result of the students’ surveys and interviews, it is apparent that students structure elements of talk in a different way than teachers. While teachers’ survey responses lead to two distinct understandings of talk approaches which aligned with theory, students merged some dialogic and authoritative elements such that an approach focusing on the science story emerged. There were elements of both dialogic and authoritative approaches that students found to be highly important during instruction. Secondary science students have had many years of experience with authoritative approaches to discussions (Baird, Gunstone, Penna, Fensham, & White, 1990; Lemke, 1990) and seem to expect it (Bleicher, Tobin, & McRobbie, 2003). The results of the surveys and interviews would suggest however that although students want to be able to contribute their ideas about science content, in the end, they want the teacher to guide them to a scientifically acceptable understanding of phenomena.

Recent work by Aguiar, Mortimer & Scott (2010) refers to the importance of considering the students’ views and intentions towards participating in science discussions, but their work is the result of observing students’ questioning during classes rather than surveying their beliefs about various elements of talk. In both student surveys and interviews, it was apparent that students place a high value on elements of both dialogic and authoritative talk. They also conceptualized these elements such that four
distinct components emerged suggesting a more complex perspective about the interactions that occur during science instruction. Instead of a dichotomous view of dialogic and authoritative approaches, students’ responses suggested that they understand talk as including dialogic interactions, understanding the science story, class management, and the assessment of their knowledge.

By far, students ranked dialogic elements and the teacher’s role in setting forth the science story as the most important elements of whole-class discussions. Science students in this study wanted the teacher to guide them towards the scientific way of thinking. Similar alignment between science teachers’ tendency towards authoritative discussion and their students’ expectations for talk during whole-class discussions has been documented in other studies (Bleicher et al., 1995; McRobbie & Tobin, 1995). Students at the secondary level seek out the guidance of teachers in establishing the scientific point of view, but in the case of the present study, they also wanted the opportunity to engage in the discussion by voicing their understandings and perspectives. This is in line with Aguiar et al. (2010) when they present the dialogic and authoritative dimension of science discussions as being “complementary forces” (p. 190). Other studies have suggested that dialogic interactions by themselves are not perceived to be valuable school work by students as well as teachers (Anderson, 2006; Russell & Martin, 2007). In the end, at the secondary level, there is an expectation that specific, well-accepted scientific concepts will be clearly established in lessons, not only the teachers in the objectives that they write, but also on the part of the students. Because of this epistemological framing on the part of both the teachers and students focused on learning
The facts of science, shifting away from authoritative discussions is difficult (McRobbie & Tobin, 1995). The persistence of traditional, teacher-centered talk in spite of reform movements is evidence of this. While science education research has continually focused on the teacher’s role in shifting discourse, student expectations for whole-class discussions may play at least an equal role in maintaining the authoritative focus that is observed during science instruction.

*Personal Factors are Related to Teachers’ Self-Efficacy Beliefs*

One possible reason for why teachers are not shifting away from authoritative discussions when they believe that dialogic approaches are more valuable for student learning may be related to their self-efficacy in directing whole-class discussions. Teachers’ self-efficacy scores about their ability to engage in student-centered, whole-class discussions were significantly related to personal factors and not the context factors included in this study. Specifically, those teachers who reported strong content knowledge and pedagogical knowledge relative to guiding whole-class discussions were more likely to receive a higher score on the self-efficacy scale. Previous research has discussed the importance of teachers’ content knowledge on the type of instruction that can occur in the classroom (Carlsen, 1993, Jones & Carter, 2007). While the findings in this study serves to support this idea that there is a positive relationship between teachers’ content knowledge and their sense of efficacy using discussions for student learning, the more significant finding was that teachers’ self-efficacy is positively related to their knowledge of strategies to guide talk. This is especially noteworthy since 40% of the
teachers in this study reported never having taken a course or workshop which focused on strategies for guiding science talk during whole-class discussions.

While teachers in this study believed that dialogic elements of whole-class discussions were more important for developing student understanding than authoritative elements, Roehler et al. (1988) argue that beliefs about instruction cannot override teachers’ knowledge of strategies while lessons are occurring in real-time. Even if teachers believe that dialogic talk is more important for learning, they either know or do not know how to bring about dialogic interactions in their class. Therefore, while beliefs will influence a teacher’s predisposition to approaching talk in a certain way, the shift cannot occur without sufficient knowledge of practices. The lack of opportunities for teachers to engage in professional development discussing how to engage in whole-class discussions is therefore problematic.

Science teachers need to become more aware of strategies that can be used to shift talk away from the traditional IRE pattern towards developing students’ thinking (Harris, Phillips & Penuel, in press; Jiménez-Aleixandre et al., 2000; Mercer & Littleton, 2007; Oliveira, 2010). A two-year study by Louca, Zacharia, & Tzialli (2012) looked specifically at the complexities of engaging students in discussions from the teachers’ point of view. They explained that as discussions are occurring in real-time, teachers are constantly processing what they are hearing and deciding how to respond. They concluded that when teachers have a limited knowledge of strategies with which to engage in discussions, the extent to which they can respond differently to student contributions is limited.
Although awareness of strategies is important for change (Enyedy, Goldberg, & Welsh, 2006), teachers may still not have the skills to make the change occur in their classroom instruction (Jiménez-Aleixandre et al., 2000; Tobin, Briscoe, & Holman, 1990). Simply knowing strategies for whole-class discussions is therefore insufficient. van Es and Sherin (2002) argue that part of the processing that teachers must engage in during science discussions is an interpretation of the students’ contributions so that appropriate actions can be taken. They suggest that teachers must learn how to “notice” student contributions in relation to broader principles in order to respond in different ways.

Ms. Romac is a case in point. When reflecting on her class discussions, she stated that the involvement of more students in the discussion would have made it better. Scott et al. (2006) state that many teachers confuse dialogic teaching with interactive, authoritative teaching. While it is true that Ms. Romac may not know what strategies she can use to shift discussions towards being more dialogic, what she is “noticing” about the discussions, namely the number of contributions as opposed to the substance of the contributions, is also significant. While her use of questioning was shown to change the extent to which students contributed more reasoned responses to discussions, her use of this strategy was not a conscious one. The ability of teachers to notice strategies in practice allows them to use them appropriately in response to student contributions.

Research has shown that teachers do not shift discussions away from more authoritative forms of discourse even when strategies are provided in curriculum materials (Alozie et al. 2010; McNeill & Pimentel, 2011), this may be happening because
teachers are not skilled at interpreting the discussion in such a way that they notice
dialogic or authoritative approaches as distinct types of interactions. Aguiar et al. (2012)
suggest that as teachers gain expertise in dealing with student dialogic contributions, they
will be better prepared to direct the discussions that occur in science lessons, but part of
that expertise may be associated with learning vocabulary that allows them to describe
and notice the interactions that are taking place during instruction (McRobbie & Tobin,
1995; Oliveira, 2010). The implications of this will be discussed later in this chapter.

*Contextual Factors Play a Role in Teachers’ Beliefs about Whole-Class Discussions*

While teachers’ abilities to notice and use various strategies during whole-class
discussions may be one reason for the persistence of teacher-directed science instruction
when they believe dialogic elements of talk are more important for learning, the
misalignment between beliefs and practices may also be the result of perceived
constraints due to the environment or context of the instruction (Lyons, Freitag, &
Hewson, 1997). Many other studies have discussed the tension that teachers feel between
providing opportunities for students to engage in meaningful dialogue and implementing
the curriculum that has been set forth by their schools (Alozie et al., 2010; Mercer, 1995;
Scott et al, 2006; van Zee et al, 2001). The present findings from the teacher survey
suggest that teachers continue to see the present curricular expectations as well as class
size to be factors that limit more reform-based approaches to whole-class discussions.
Interestingly, the majority of teachers in this study did not perceive expectations of
administrators or parents to play a significant role in the types of discussions that took
place in their class. Also, school level variables tested in this dissertation such as average

school SES did not seem to explain the differences in overall beliefs as measured by the scales. While the small sample may account for this, it may be that teachers’ beliefs about approaches to whole-class discussions are not related to these broader context factors, but more immediate factors like their preparation and experience as well as their perceptions of the students they are interacting with.

Student factors such as motivation and behavior were rated by teachers as having high importance in the quality and frequency of whole-class discussions. Statistical analysis suggested that teachers’ perceptions of student motivation might be related to their outcome expectancy beliefs of whole-class discussions. In other words, the effectiveness of whole-class discussions to bring about student learning may depend on how motivated students are in the process. Unfortunately, due to the limited number of teachers participating in the study from urban schools, the relationship of school-level factors and student motivation on teachers outcome expectancy beliefs could not be clearly identified. This limitation of the study was especially frustrating given that outcome expectancy beliefs seemed to be the only teacher beliefs investigated in this dissertation that showed some variability between schools.

While HLM results were inconclusive with respect to school-level factors and teachers’ outcome expectancy beliefs, an indication that school-level factors may influence teacher beliefs was apparent when examining the results of teacher survey responses to the importance of students’ academic ability in the quality of discussions. When the responses of all teachers were considered in the Chi-Square analysis, thereby providing a more diverse group of teacher responses than was included in HLM, a
significantly higher number of teachers in lower SES schools stated that their students’ limited academic ability was highly important in limiting science talk quality. This significant difference was not found with other student qualities like motivation, behavior or even content knowledge, which are usually perceived as alterable qualities. While the result of this test does not displace the insignificant results of the HLM, they provide some indication that there are school-level variables worth considering in future research.

In the case of teachers’ beliefs about student academic ability, other studies have shown that urban teachers are more likely to have lower expectations for their students’ abilities (Galley, 2001; Hewson, Kahle, Scantlebury, & Davies, 2001). Further investigation of this possibility is important in regards to shifting classroom discussions because teachers of poor or working class students who had lower expectations of what their students could learn tended to focus more on facts and basic skill acquisition, while those teachers in affluent communities stressed knowledge as discovery, creativity and thinking (Anyon, 1981).

Moore (2002) suggests that disparities science teachers perceive of urban students may be the result of differences in identity and culture that exist because many of those teachers have backgrounds that are more aligned with school culture instead of their students’ culture. Urban youth have alternative ways of participating in science discussions that are not well understood by secondary teachers, therefore student contributions in this setting can be misinterpreted such that the richness of students’ responses are not acknowledged and further interactions are not encouraged (Emdin, 2011).
Failure to engage in dialogic forms of discourse, especially with underrepresented students, can increase the achievement gap that exists among sub-urban and urban students. If students are not allowed or encouraged to speak to each other or they are prevented from explaining themselves, the prioritization of correctness implicitly discourages students from exposing their thinking during discussions (Hutchinson & Hammer, 2010). Although the authoritative approach may serve to increase the efficiency of content coverage and orderliness of the class, it does not necessarily result in greater students’ learning. Previous research suggests that secondary teachers who reported a higher frequency of students engaging in argument and sharing ideas and a lower percentage of time lecturing had greater student learning of science concepts and scientific inquiry practices (McNeill, Pimentel & Strauss, in press). Furthermore, research suggests that a focus on conceptual understanding and depth of knowledge at the secondary level is associated with higher performance in college level courses (Schwartz, Sadler, Sonnert, & Tai, 2009).

Students’ Framing of Whole-Class Discussions Impacts the Dynamics of Talk

Students participate less productively in whole-class discussions that are authoritative and focused only on providing correct answers to closed questions (Alpert, 1987; Furtak & Ruiz-Primo, 2008, Hutchinson & Hammer, 2010). In both surveys and interviews, many students in this study stated that they were most likely to contribute to discussions when they were certain they could provide the right answer, but this was not true of all students. The manner in which students in this study framed participation in
whole-class discussions, both epistemologically and socially, was related to their goals for talking and the level of their science class.

Hutchinson and Hammer (2010) described two epistemological frames that students can take when participating in whole-class discussions: “the classroom game” and “making sense of phenomena” (p. 510). Students in this study who actively participated in class discussions by asking questions and providing extensions associated with the topic believed that asking questions and participating helped them and others to better understand the scientific concepts. Instead of viewing class discussions as a game where they are demonstrating their knowledge, they were more likely to frame the discussion as place for meaning making. Furthermore, students who participated more productively in discussions had a different perspective on their role in relation to others. They believed that their questions and comments would benefit everyone in the class and that it was their role to help other students in the class to learn. Those students who contributed least to discussions were more likely to view their participation in class discussions as interruptions that would get in the way of other students’ learning. This difference in students’ social framing may play a significant role in the dynamics of whole-class discussions regardless of the strategies that the teacher is using, especially at the secondary level.

Social dynamics are constantly at play within high school science classrooms. When participating in discussions, students are negotiating their identity and are not necessarily “free to be whomever they want to be in science” (Shanahan & Nieswandt, 2011, p. 367). Students’ willingness to participate more actively in discussions was
related to how comfortable they felt either because of personal attributes making them less self-conscious or because they were familiar and felt safe with the members of the class. While shifting towards less authoritative discussions will not change a student’s personality, it does shift the epistemological frame towards being more productive and focusing more on making sense of phenomena as opposed to knowing the right answer (Hutchinson & Hammer, 2010). This would allow students to participate in a way that values thinking and reasoning more than simply facts, thereby making them more apt to take on a scientific identity. One challenge however may be how to get students who have been so accustomed to framing science discussions in an authoritative way to buy into a more dialogic, meaning focused way of talking.

Differences in students’ framing of whole-class discussions, especially as it related to their role, were observed at more than just the individual level. Those students who were enrolled in the lowest level course described their role in a more passive and socially isolating way than students in the other levels. While the majority of students in the general class identified themselves as White, placing them in the majority with respect to race, these students were less likely to have a parent with a post-secondary degree. With fewer opportunities to engage in scientific or academic discourse at home (Lee & Luykx, 2007), these students may feel unqualified to participate productively in class discussions. Other researchers have suggested that because of the sociocultural nature of science discourse, participation in discussions by students of non-mainstream backgrounds may include issues of identity appropriation or enculturation (Brown, Reveles, & Kelly, 2005). It is not possible from this study to say whether the framing
that general level students took towards whole-class discussions was a result of experiences at home, their previous experiences in science classes, their approach to identity or a combination of all these factors. The stark differences in approaches to talk related to class level however is worth further research. It would seem that engaging students of less privileged backgrounds may require more than simply a change in teacher strategies, but also intentional supports that help students to shift their sense of agency in the science classroom.

Limitations

While this dissertation sheds light on teachers’ and students’ beliefs about whole-class discussions and possible factors that are related to these beliefs, it presents possible relationships between factors and beliefs only. It is not possible to make causal claims given the methods employed. Furthermore, although there appears to be some school-level predictors such as average student socioeconomic status that relate to teachers’ beliefs about outcome expectancies, the limited number of participants in the statewide survey makes it impossible to clearly understand whether a relationship truly exists. Especially with respect to the outcome expectancy scale, further refinement is necessary.

While the statewide survey was a beginning in understanding teachers’ beliefs about talk more generally, a study of a more populated state utilizing random sampling will serve to better understand any relationship that may exist. Also, it is important to restate that while this study explores teachers’ beliefs, it does not establish any relationship between teachers’ beliefs as measured by the four scales and the occurrence of specific approaches to talk during instruction.
As is true of case studies, I acknowledge that by using one case to study beliefs that are context dependent, it is not possible to generalize about all secondary science teachers. However, the case study did provide a look at how one teacher approached talk in classes of different levels. With regards to the students, it is true that as part of the case study, these students represented a predominantly White student demographic in a suburban area. While there are findings that suggest that students’ socioeconomic status may play a role in their approach to talk, these findings are not intended to explain differences in talk that may exist in urban schools where the population of students is more diverse.

Lastly, while research suggests that teachers’ positive identification with school culture and the middle class interfere with their ability to interact dialogically with students of less privileged backgrounds, this study did not investigate teachers’ backgrounds regarding socioeconomics or ethnicity. Because this information was not requested on the survey, it is not possible to know if these factors played any role in teachers’ beliefs about approaches to talk.

Implications

While the teachers in this study showed more positive beliefs about dialogic than authoritative approaches to whole-class discussions, many of them have not participated in opportunities to develop their pedagogical knowledge of talk strategies. This has implications both in terms of the teachers’ ability to appropriately shift between approaches and their ability to help establish productive epistemological and social frames for students. While strong disciplinary content knowledge has been associated
with more productive class discussions (Carlsen, 1993), the effective management of whole-class discussions also requires pedagogical knowledge (Shulman, 1983). Many secondary science teachers do not have an adequate understanding and vocabulary to reflect on the types of talk that occurs in their classes (McRobbie & Tobin, 1995; Oliveira, 2010). Explicit instruction about guiding talk during whole-class discussions is an important first step for both novice teachers and experienced teachers if more dialogic, student-centered talk is to occur.

Especially at the high school level where disciplinary content knowledge is perceived as the main requirement for science instruction, teachers need opportunities to reflect on their practice with a more comprehensive lens. Research has shown that science teachers who have engaged in professional development that explicitly defined elements of discussion strategies and provided opportunities for them to notice more dialogic discourse strategies by way of video case analysis have shifted towards more dialogic forms of instruction (Oliveira, 2010; Sherin & van Es, 2005). More professional development, that helps teachers to identify what type of talk is occurring in their classes as well as distinguish when different approaches are most appropriate, is required (Scott et al., 2006). While reform documents have repeatedly called for a shift in discourse and the teachers in this study seem to acknowledge the value of this shift, the lack of opportunities for teachers to learn about the strategies continues to be a limiting factor.

Beyond strategies however, teachers must also have opportunities to reflect on how they specifically are using the strategies and framing the discussions in their class. Urban middle school teachers who participated in video clubs reflecting on videos of
interactions within their own classrooms were shown to shift their instruction to include more of a focus on student thinking (van Es & Sherin, 2009). In order to shift talk, high school science teachers need time to reflect on their instruction, identifying the type of talk that is happening in their classes and their role in directing that talk.

Once teachers themselves are clear on how they want the framing of whole-class discussions to occur, it is also important that they explicitly communicate their expectations to students (Berland & Hammer, 2012). Given that students have been taught to frame science discussions authoritatively, teachers will need to be persistent throughout the year in order for students to better understand their role in the different frames that may be used by the teacher during instruction. This may include designing lessons that specifically engage students in more dialogic types of talk as well as incorporating more open questions during whole-class discussions. Scott and Ametller (2007) propose some steps that can be taken to involve students more dialogically especially by having students express their initial understandings of scientific concepts before engaging in the authoritative point of view and also providing opportunities for students to express their understandings of what is being taught by the teacher.

Attention must also be given to classroom culture and its role in the dynamics of talk during whole-class discussions. While other researchers have discussed the role of personal identity and diverse cultural backgrounds in mediating student participation in science (Brown et al., 2005; Edmin, 2011), this dissertation suggests that classroom culture and sense of community may also be important in allowing students to feel free to express themselves with their peers. Students in general establish identities whenever
they speak in a class setting, teachers must therefore be more cognizant of how they are framing student interactions (Oliveira, Akerson & Oldfield; 2012) and more explicitly establish a cooperative climate where teaching and learning is the role of all participants. Part of this may be moving towards more dialogic talk that places the emphasis on understanding over providing correct answers. However, another aspect may be that teachers provide time for students to interact socially in many different groups so that they can familiarize themselves with the other students in the room. Unlike elementary and middle schools, high school students are less likely to know all of the students in their classes. Because of scheduling processes and the greater number of students in the high school setting, students do not move through their day with the same peers in all of their classes. Many sections exist for most of the courses they enroll in, so many times students are not familiar with the other students in the class. While elementary and middle schools provide some time for social interactions including recess, the high school classes tend to overlook the social aspect of the class for many reasons including time constraints. Further research investigating how secondary teachers establish classroom cultures that are more conducive for dialogic talk will therefore broaden our current understanding of how whole-class discussions can change.

While these implications are presented in a way that may suggest shifting whole-class discussions towards being dialogic is a simple process, this is not the intention. If anything, this dissertation serves to support the idea that there are many elements and factors at play in the secondary science classroom. It is clear that many of the factors influencing talk are out of the teachers’ control, such as curricular demands and class
size, and some factors have not been identified. However, this dissertation serves to set forth some aspects of whole-class discussions that can be better supported and may therefore have some impact in helping to reform the types of science talk that happens in high school classrooms.
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Appendix A

Statewide Survey

A2. Science Talk Efficacy Beliefs Scale (STEBS) Page 197
A5. Factors Influencing Talk Likert Scales Page 203
A6. Background Information Section Page 205
Appendix A1: Context Questions

Before answering the questions in this survey, choose one of your classes as the context for your responses.

How many students are in the class? _____

On a scale from 0-10 (where 0 is significantly below average or problematic and 10 is significantly above average or superior), how would you rate

1. your students’ overall motivation for learning science?

2. your students’ overall academic ability?

3. your students’ overall English language proficiency?

4. your students’ overall behavior?

5. your students’ previous experience with talking about science during class discussions?

6. your students’ science content knowledge base?

7. your confidence with teaching the science content in this class?

8. your knowledge of different approaches to guide talk in your class?

9. your previous experience engaging your students in whole-class discussions?
Appendix A2: Science Teacher Efficacy Beliefs Scale (STEBS)
Using Mercer & Littleton, 2007 and Scott et al., 2006
Response Scale (0-10) where 0= total disagreement with the statement and 10= total agreement with the statement

Personal Science Talk Efficacy Beliefs (2,3,5,6,8,12,17, 18,19, 21 22 23 24)

Prompt

2  I am continually finding better ways to engage my students in talking about different perspectives in science.  +

3  Even when I try very hard, I don’t teach as well when class discussions diverge from the specific content I planned to talk about.  -

5  I know the steps necessary to effectively help my students to build on and apply new ideas through talking with others.  +

6  I am not very successful in getting my students to listen to others.  -

8  I generally have difficulty teaching students how to make sense of other students’ ideas.  -

12 I understand science concepts well enough to be effective in encouraging students to contribute their ideas during lessons.  +

17 I find it difficult to allow discussions in science to veer away from my intended lesson plan when students initiate new ideas about the content we’re studying.  -

18 I am typically successful at having students elaborate on their reasoning during science discussions.  +
19 I wonder if I have the necessary skills to orchestrate effective student science talk during lessons.

21 Given a choice, I would not invite the principal to evaluate me when the class is focused on learning science through whole-class discussion.

22 When a student has difficulty understanding a science concept, it is easier for me to help them than to engage other students in talking about their understandings about the concept.

23 When teaching science, I am good at getting students to talk more to each other during class discussions than directly to me.

24 I don’t know what to do to get students to take a more active role in science talk during lessons.
Appendix A3: Science Talk Outcome Expectancy Scale (STOES)


Using Mercer & Littleton, 2007 and Scott et al., 2006

Response Scale (0-10) where 0= total disagreement with the statement and 10= total agreement with the statement

Prompt

1. When a student does better than usual in science, it is often because the teacher made an extra effort to talk to that student about their ideas and understandings. +

4. When student learning improves, it is most often due to their teacher having found more effective approaches towards talking with them about science. +

7. If students are underachieving in science, it is partly due to classroom science talk which limits student contributions. +

9. The inadequacy of students’ science backgrounds can be overcome by effective teaching approaches that encourage students to talk about their understandings. +

10. The difficulties of many students in learning science cannot be overcome by their teacher’s approach to dialogue in class. -

11. When a low achieving child progresses in science, it is usually due to extra attention given by the teacher during class discussions to help the student reflect on his/her thinking. +

13. Increased effort by the teacher in discussing student understandings and reasoning during class makes little difference in most students’ science achievement. -
14 Rigidly steering science discussions is one of the most effective strategies teachers have for maximizing student learning.

15 If parents comment that their child is showing more interest in science at school, it is due in part to the teacher’s approach to talk during instruction.

16 Effectiveness increasing student participation in talk during science lessons has little influence on the achievement of students with low motivation.

20 Even teachers with good ability orchestrating talk during science lessons cannot help some kids learn science.
Appendix A4: Science Talk Approach Scale
Features described in Scott, Mortimer, & Aguiar 2006

Directions: Please rank the extent to which the following features are important in effective science talk during whole-class discussions in which the purpose is to develop students’ understandings of a scientific concept.

Scale: extremely important, very important, somewhat important or not at all important

<table>
<thead>
<tr>
<th>Talk Type</th>
<th>Feature Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1. Teacher evaluates and provides feedback immediately after student contributions.</td>
</tr>
<tr>
<td>D</td>
<td>2. Teacher asks students to clarify or elaborate on their responses.</td>
</tr>
<tr>
<td>D</td>
<td>3. Teacher and students build on each other’s ideas.</td>
</tr>
<tr>
<td>A</td>
<td>4. Teacher focuses only on the scientific explanation for phenomena.</td>
</tr>
<tr>
<td>D</td>
<td>5. Students contribute personal points of view.</td>
</tr>
<tr>
<td>A</td>
<td>6. Teacher rigidly guides the direction of the discussion.</td>
</tr>
<tr>
<td>A</td>
<td>7. Teacher reshapes and elaborates on student responses.</td>
</tr>
<tr>
<td>D</td>
<td>8. Teacher is open to different points of view.</td>
</tr>
</tbody>
</table>
9. Students initiate new ideas into the discussion. D

10. Students provide reasoning when they contribute to discussions. D

11. Students talk directly to each other. D

12. Teacher questions students about content facts and vocabulary. A

13. Students contribute to the discussion only when called upon by a teacher. A
Appendix A5: Factors Influencing Talk Likert Scales

Frequency
Based on Jones & Carter, 2007

How important are the following factors in limiting the frequency of science talk during whole-class discussions in which the purpose is to explore and develop students’ understandings of a scientific concept? (Extremely important, Very important, Somewhat important, Not at all important)

Index: Context Factors (non-student source)

  Administrator expectations
  Colleague expectations
  Parent expectations
  Approach of our current school curriculum
  Lack of time due to content coverage expectations
  Large Class Size

Index: Context Factors (student source)

  Limited student content knowledge
  Limited student experience with science talk
  Limited student motivation
  Limited student academic ability
  Limited student English language proficiency
  Student expectations
  Student disciplinary/behavioral issues

Index: Personal Factors

  Your experience guiding student science talk.
  Your confidence with the content being taught.
  Your knowledge of instructional strategies to support this type of talk.
Factors Influencing Talk Likert Scales
Quality
Based on Jones & Carter, 2007

How important are the following factors in limiting the quality of science talk during whole-class discussions in which the purpose is to explore and develop students’ understandings of a scientific concept? (Extremely important, Very important, Somewhat important, Not at all important)

Index: Context Factors (non-student)
- Administrator expectations
- Colleague expectations
- Parent expectations
- Approach of our current school curriculum
- Lack of time due to content coverage expectations
- Large Class Size

Index: Context Factors (student)
- Limited student content knowledge
- Limited student experience with science talk
- Limited student motivation
- Limited student academic ability
- Limited student English language proficiency
- Student expectations
- Student disciplinary/behavioral issues

Index: Personal Factors
- Your experience guiding student science talk.
- Your confidence with the content being taught.
- Your knowledge about instructional strategies to support this type of talk.
Appendix A6: Background Information

School

Years of Experience Teaching

Years of Experience Teaching Science

Undergraduate degree

  Biology
  Chemistry
  Physics
  Other

Graduate degree (Check all that apply)

  None
  Masters in education
  Masters in a science discipline
  PhD in education
  PhD in a science discipline
  Other

Certifications (Check all that apply)

  Secondary General Science
  Secondary Biological Sciences
  Secondary Chemistry
  Secondary Physics
  Other

How many courses have you taken that focused on strategies for guiding science talk in your class?

How many workshops have you attended that focused on strategies for guiding science talk in your class?
Appendix B: Teacher Pre-Observation Interview Protocol

Thank you again for agreeing to this interview. I am very excited to get your thoughts on topics that I find very interesting. I will start the interview by asking some background questions. Then I’ll ask you about your beliefs about the purpose science education. I’m also interested in knowing your thoughts about your role as a science teacher and how you’ve decided to structure your class, so I’ll ask some questions about that. To finish off, I’ll ask you for some thoughts about your approach to talk during lessons and the factors you think that influence the effectiveness of that talk. If at anytime you feel the need to end this interview, please feel free to just tell me and I will stop. Also, you are not obligated to answer all of the questions I am posing. Please feel free to let me know if there are any questions you would prefer not to answer. The information that I obtain from our discussion will be used in my dissertation and may be the source of data for future publications, however I will your identity will be held confidential. Pseudonyms will be used for all names that may come up during our discussion including your name and the school’s name.

Do you have any questions or concerns before we begin?

Do you feel comfortable proceeding with this interview?

Background:

1. How long have you been a science teacher?

2. Why did you decide to become a science teacher?
   - Where there other careers that you also considered pursuing?

3. Growing up, what were your experiences with science?
   - Did you like science as a student?
   - Is there a favorite science teacher that comes to mind? What was she or he like?
   - Did you major in science in college?

4. At any point, have you done scientific research in a laboratory or in the field?
   - If so, how did this influence you as a science teacher?

It’s funny how in some ways, we science educators have had many similar experiences on the road to teaching, but at the same time the experiences are so unique. I want to continue now with some questions that will give me a feeling for your beliefs as a science teacher.
Beliefs:

5. What do you think is the purpose of a science education for high school students?
   - Do you see many of your students becoming scientists? What makes you think this?
   - Does a science education serve a greater purpose than just knowing science or getting a job in the sciences? Please provide some examples.

6. How would you define your role as a science teacher?
   - What are your goals?
   - If I asked you to describe yourself as a science teacher, what would you say?
   - Is there a difference between teaching science and other subjects? If so, what is it?

7. What are some of the challenges you face to accomplishing the overall goals you mentioned before?

I think that these ideas are so very important. Next, I want to end by getting some of your thoughts on the type of talk that occurs in your class, if that’s okay?

8. How would you describe the whole class discussions that take place in your class during lessons?
   - How important do you think whole class discussions are in achieving the goals you have set for your students?
   - What role do you play in whole class discussions?
   - What is your overall approach to talk during whole class discussions during lessons? What is your primary concern and how do you obtain information about it?

9. What are the main challenges you see to having productive talk during whole class discussions?
   - What strategies do you use to overcome those challenges?
Wow Ms. Romac. You’ve definitely given me a lot of food for thought. I look forward to working with you and your class more throughout the year. When I have completed the transcript, I’ll give you a copy for your feedback. I am most concerned in whether you think the interview adequately and accurately captured your thoughts about the questions I asked.
Appendix C: Teacher Stimulated Recall Interview Protocol

Thank you again for agreeing to this interview. This time I am interested in exploring your thoughts about specific interactions that occurred in your class. My primary focus will be on the talk that has occurred and your understanding of what is influencing the interactions. If at anytime you feel the need to end this interview, please feel free to just tell me and I will stop. Also, you are not obligated to answer all of the questions I am posing. Please feel free to let me know if there are any questions you would prefer not to answer. The information that I obtain from our discussion will be used in my dissertation and may be the source of data for future publications, however I will your identity will be held confidential. Pseudonyms will be used for all names that may come up during our discussion including your name and the school’s name.

The following questions will be asked for each clip.

What were you thinking during this clip?

What was the purpose in the way you responded?

You said that the overall purpose of the lesson was ___________. Do you think it was happening? Why?

After all clips have been viewed from the three different levels of classes, the following questions will be asked.

Do you see any trends or differences among all the clips that are interesting to you?

How do you think that the different contexts associated with each class influenced the talk that occurred during the whole-class discussions?
Appendix D: Student Survey

Features of Whole Class Discussion

Directions: Please rank how important you think the following features are during whole-class discussions by circling your choice on the scale.

1. Teacher evaluates and provides feedback immediately after student contributions.

   Extremely Important  Very Important  Somewhat Important  Not At all

2. Teacher asks students to clarify or elaborate on their responses.

   Extremely Important  Very Important  Somewhat Important  Not At all

3. Teacher and students build on each other’s ideas.

   Extremely Important  Very Important  Somewhat Important  Not At all

4. Teacher focuses on science point of view at all times.

   Extremely Important  Very Important  Somewhat Important  Not At all

5. Students contribute personal points of view.

   Extremely Important  Very Important  Somewhat Important  Not At all

6. Teacher rigidly guides the direction of the discussion.

   Extremely Important  Very Important  Somewhat Important  Not At all

7. Teacher reshapes and elaborates on student responses.

   Extremely Important  Very Important  Somewhat Important  Not At all

8. Teacher is open to different points of view.

   Extremely Important  Very Important  Somewhat Important  Not At all

9. Students initiate new ideas into the discussion.

   Extremely Important  Very Important  Somewhat Important  Not At all

10. Students provide reasoning when they contribute to discussions.

    Extremely Important  Very Important  Somewhat Important  Not At all
11. Students talk directly to each other.
Extremely Important     Very Important     Somewhat Important     Not At all

12. Teacher questions students about content facts and vocabulary.
Extremely Important     Very Important     Somewhat Important     Not At all

13. Students contribute to the discussion only when called upon by a teacher.
Extremely Important     Very Important     Somewhat Important     Not At all

Directions: Read each prompt below and complete the sentence so that it reflects what you think about participating in science talk during lessons.

1. The main reason for us to have whole-class discussions in science is…

2. There are times that I have a question or want to add something to the class discussion but I don’t because…

3. I am most likely to say something in science class lessons when…

4. The role of my teacher in class discussions is …

5. The role of the students in the class during science discussions is…. 
**Background information:**

1. What is your gender (circle one)?
   Female   Male

2. What is your ethnicity?  ___________________________________________

3. Is any member of your immediate family involved in a science-related career (circle one)?  Yes  No

4. What is the highest level of education obtained by your parents or guardian? (circle one)?
   High School – No Diploma
   High School Diploma
   Associates Degree
   Bachelors Degree
   Masters Degree
   Doctorate
   Other (Please Specify)__________________________________________

5. What was your semester grade in this chemistry class?  ____________

___________________________________________
Class Period_____________
Name __________________________________________
(ID number will be assigned to student and Name will be detached from the survey sheet)
Appendix E: Student Interview Protocol

Thank you again for agreeing to this interview. I am interested in exploring your thoughts about specific interactions that occurred during science class. My primary focus will be on the talk that occurred and what you think about it. If at anytime you feel the need to end this interview, please feel free to just tell me and I will stop. Also, you are not obligated to answer all of the questions I am posing. Please feel free to let me know if there are any questions you would prefer not to answer. The information that I obtain from our discussion will be used in my dissertation and may be the source of data for future publications, however I will your identity will be held confidential. Pseudonyms will be used for all names that may come up during our discussion including your name and the school’s name.

The following questions will be asked for each clip.

1. How do you feel about the type of discussion that’s going on in this clip?
2. Do you think this was a good example of the type of discussions you like your science class to have?
3. If you contributed, what made you comfortable about talking?
4. If you didn’t contribute, why didn’t you?
5. How important do you think the talking that occurred in this lesson was in learning the chemistry material Ms. C wanted you to learn?
6. Do you wish the discussion had been different? If so, how?
7. What influences whether or not you participate in class discussions in general?

Referring to the survey:

8. On the survey you stated that referring to student response of interest, could you say a little more about what you meant by that