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The Perceptions of Elementary School Teachers Regarding Their Efforts to Help Students Utilize Student-to-Student Discourse in Science

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The Perceptions of Elementary School Teachers Regarding Their Efforts to Help Students Utilize Student-to-Student Discourse in Science

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Approvals

In the judgment of the following signatories, this Dissertation meets the academic standards that have been established for the Doctor of Philosophy degree.

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Abstract

The purpose of this phenomenological study was to examine the perceptions of elementary teachers who teach science as opposed to science teacher specialists regarding their efforts to help students use student-to-student discourse for improving science learning. A growing body of research confirms the importance of a) student-to-student discourse for making meaning of science ideas and b) moving students' conceptual development towards a more scientific understanding of the natural world. Based on those foundations, the three research questions that guided this study examined the value elementary teachers place on student-to-student discourse, the various approaches teachers employ to promote the use of student-to-student discourse for learning science, and the factors and conditions that promote and inhibit the use of student-to-student discourse as an effective pedagogical strategy in elementary science. Data were gathered from 23 elementary teachers in a single district using an on-line survey and follow-up interviews with 8 teachers. All data were analyzed and evolving themes led to the following findings: (1) elementary teachers value student-to-student discourse in science, (2) teachers desire to increase time using student-to-student discourse, (3) teachers use a limited number of student-to-student discourse strategies to increase student learning in science, (4) teachers use student-to-student discourse as formative assessment to determine student learning in science, (5) professional development focusing on approaches to student-to-student discourse develops teachers' capacity for effective implementation, (6) teachers perceive school administrators' knowledge of and support for student-to-student discourse as beneficial, (7) time and scheduling constraints limit the use of student-to-student discourse in science. Implications of this study included the necessity of school districts to focus on student-to-student discourse in science, provide teacher and administrator professional development regarding student-to-

student discourse instructional strategies, and promote collaboration across disciplines. This study suggests that future research be conducted regarding the role of administrators in fostering student-to-student discourse, the perspectives of secondary teachers implementing student-to-student discourse, the use of student-to-student discourse in other subjects, and leadership approaches to broadening the study across districts.

Key words: discourse, elementary, student-to-student, science, science education

Dedication

Edward Craddock
my greatest believer, supporter, and friend.

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CHAPTER ONE: INTRODUCTION

The purpose of doing science is to constantly test and retest the current understanding of phenomena to determine if that conception remains or must change. (National Research Council (U.S.), 2012). The field of science has always been evolving and is currently changing rapidly; as a result, the value of teaching students to learn and memorize facts is greatly diminished. Science learning should be about changing students' conception of the natural world rather than memorization of facts (R. A. Duschl, Schweingruber, & Shouse, 2007). In broader terms, the purpose of school is to prepare students to be adults with the ability to make informed choices and solve problems as full participants in their own lives (Barnes, 2008; R. Duschl, 2008). In a world increasingly reliant on science and on technologies, science education should help students understand that science and engineering permeate every aspect of modern life (National Research Council (U.S.), 2012). However, according to recent studies (National Research Council (U.S.), 2012; National Research Council, 2007), instructional strategies currently used fall short of preparing the majority of students to be scientifically literate.

Student-to-student discourse in science has the potential to engage students in the subject matter, immerse them in the learning experience, and facilitate the acquisition of knowledge and ways of talking about science. Teaching students to engage in discourse in science has the potential to develop a scientifically literate citizenry, in which people think critically about the world around them, solve problems based on available evidence, and evaluate alternative explanations. Critical thinking and problem solving learned in the science classroom has the potential to transfer to effective decision-making about important life-situations. Further, student-to-student discourse provides the opportunity for all students to engage equally in the process of learning science through the communication and examination of diverse ideas.

Although some students can and do learn science without the use of discourse in the classroom, research has shown that discourse is effective for reaching larger audiences of students and developing 21st century decision-making skills (R. A. Duschl et al., 2007; Sarah Michaels, O'Connor, & Resnick, 2008). Therefore, by including student-to-student discourse in science, teachers help students in developing problem solving strategies for use as an adult as effective decision-makers in modern life.

As a former elementary teacher of science and in my current position as a Kindergarten through Grade Eight curriculum coordinator of science, my experience showed me the value of student-to-student discourse in science as an important instructional practice because it helps students to develop critical thinking and problem solving skills as well as acquire the knowledge of science. The focus of student-to-student discourse is on student thinking rather than on learning a set of facts. The power of discourse as an effective means for learning science became evident ten years later in a course titled "Listening to Children's Ideas." Discourse was used for making sense of new information, developing explanations for revised ideas, and to learn what I, or the students did not know. Through a process of interviewing students and transcribing their interviews, I began to listen more carefully to the students' ideas to discern what they did know and understand as well as to pinpoint what they did not know. It seemed that the point of learning was to become able to engage in conversations around particular areas of knowledge and to consider and argue the claims to knowledge, in other words the claim and validity of the data and the warrants that make the data the evidence. Multiple perspectives come from variation in population and in individual experiences, not everyone is the world is a white, middle-class, heterosexual female. There are variations of gender, class, race, ethnicity, sexual orientation and education in populations in the world and in classrooms. Assumptions of homogeneity,

attributions of a characteristics to a group, and assumptions of causality of particular actions often serve as bias that prevents effective discourse. The challenge is to move from our single perspective to included multiple perspectives in the classroom and engage in an inquiry with the students to understand the world scientifically. As Donald Schön eloquently described at the 1988 American Education Research Association conference it is to…

> "get in touch with what the kid knows, to be puzzled by it, to pay attention to it, to become curious about it, to listen to it, to become surprised, to do a kind of detective work on the spot whose purpose is to discover what it is the kid understands...to meet the kid where he is in his own way of knowing and understanding and then to try to help the child..."(Schön 1988)

Perhaps this interest was partially influenced by my background in Anthropology, I found that student-to-student discourse provided a treasure-trove of information on students for planning next steps for learning and strategically pairing students with peers to further their learning. Even primary aged students engaged in productive, on-topic discourse with peers, shared diverse ideas and perspectives, made sense of these ideas, and evaluated according to one or more criteria. Moving from a monolog to a conversation means learning to see outside our perspective. Students collaborated as a learning community so that all students knew and were able to do what is necessary to meet or to exceed the learning standard. As Takacs writes about cooperative argumentation, "in our classrooms we argue towards consensus rather than towards winning" (2003, p. 27). The social aspect of learning was not necessarily quiet, but it was effective.

As an evaluator of new teachers, I have observed elementary teachers lecturing, explaining, and telling science information to students. I have rarely observed teachers using

student-to-student discourse in their instructional practice. This made me wonder about teachers' perception of their professional responsibilities and knowledge of science educational strategies. In order to engage in the process and conversations, we need to reflect on our assumptions and be willing to engage with others to argue to consensus. Schön (1983) emphasizes the importance of the need to reflect in action as the life unexamined is bounded. Differentiating professionalism as a technical expert as opposed to a reflective practitioner, Schön's reflection in action allows for the process of revising thinking in an internal to external to internal cycle. The opportunity for reflection in action enables a reflective practitioner "to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique" (Schön, 1983, p. 68). Reflection in action offers the potential to reflect in the moment and step back look askance at our assumptions and notions to consider them with curiosity learn other perspectives and revise or adjust our own perspective, a self-inquiry. Teaching as a professional requires Schön's reflection in action cycle for continuous improvement of the skills and knowledge to be a skillful practitioner. While researchers have identified that best teaching practice in science is that of student-to-student discourse to develop a scientific understanding of the natural world, teachers rarely utilize this powerful practice (R. Duschl, 2008). This study was an opportunity to learn from teachers.

Statement of the Problem

The gap between the research on student-to-student discourse and the practice of teachers in their classrooms is evident (R. Duschl, 2008) but the reason teachers do not consistently employ this powerful practice is not apparent. Researchers have investigated what teachers should be doing to include student-to-student discourse (Mercer, Dawes, Wegerif, & Sams, 2004; Sarah Michaels et al., 2008). However, thus far, these authors have not explored in-depth

the teachers' perceptions of the supports and barriers to using student-to-student discourse as instructional practice for learning science. In addition, most teachers have not received pre-service educational coursework or in-service professional development in student-to-student discourse. As a result of this gap, students do not have the opportunity to learn to use student-to-student discourse to make sense of new ideas and concepts that result in conceptual understanding, thinking processes, and effective use of science in their lives. They also do not have the opportunity to experience how scientists function in the real world. In short, their science education is compromised.

The resulting consequences are a citizenry who have little background understanding of the processes and evidentiary nature of science. Although not all students go on to scientific or engineering careers, unlike prior times, some knowledge of science is required to make informed everyday decisions and engage in today's major public policy issues; such as selecting medical treatments or issues regarding the natural resources. While these require social, political, and economic solutions, these solutions must be informed by the underlying science. Students who do not engage in discourse to make sense of science concepts are often left with their intuited ideas of how the natural world works. The result is a citizenry who does not understand the underlying science, nor are they able to engage ineffective discourse to further their understanding of the issues they are asked to make decisions about. This kind of citizenry is limited in their ability to make effective decisions related to science in their daily lives or to participate and contribute to the greater society.

The Purpose of the Study

The purpose of the study is to examine the perceptions of elementary teachers regarding their efforts to use student-to-student discourse in the science classroom. The study examined

the degree to which elementary teachers of science value student-to-student discourse for improving student learning. The approaches elementary teachers report they use to promote student-to-student discourse in science were examined. The study explored teachers' perceptions about the factors and conditions they believe promotes and inhibits their use of student-to-student discourse for learning in science. Teachers' perceptions of the supports and barriers they identify as promoting and inhibiting their use of student-to-student discourse to increase student learning in science provided valuable information contributing to closing the gap between the research and current instructional practice. This research included the degree to which teachers report they are successful in using student-to-student discourse and the frequency with which teachers include student-to-student discourse in teaching science.

Three questions guided the research:

1. To what degree do elementary teachers value student-to-student discourse?
2. What are the various ways elementary teachers of science report they are using student-to-student discourse to increase student learning in science?
3. What are the supports and barriers elementary teachers of science identify as promoting and inhibiting their use of student-to-student discourse to increase student learning in science?

Definition of Terms

The following terms are used throughout the study. The meaning of each term is clarified below.

Discourse in Science: talk that engages the participants in the subject matter, immerses them in the learning experience, and facilitates the acquisition of knowledge. (James Paul Gee, 2012). In science, students engage with each other to make sense of new

information and construct meaning so they comprehend science concepts. Purposeful student-to-student discourse fosters conceptual change necessary to comprehend and learn science.

Elementary Schools: For the purpose of this research, schools offering a K-5 education.

Elementary Teachers: Elementary K-5 classroom teachers who teach science as well as many other subjects.

Perceptions: A point of view, opinion, or insight that is the product of becoming conscious of events and their connections by way of the senses and interpreting information through personal experience.

Student-to-student: Students engage with each other in productive, on topic discussions to make sense of new information. This can also be described as "socially mediated" construction of knowledge is considered to promote deep and sustained learning.

Significance of the Study

The study provided insight into the perceptions of elementary teachers regarding their efforts to help students use student-to-student discourse in the science classroom. It examined the degree to which elementary teachers of science value student-to-student discourse for improving student learning and the approaches elementary teachers reported they use to promote student-to-student discourse in science. The study investigated teachers' beliefs about the factors and conditions they believe promote and inhibit their use of student-to-student discourse for learning in science. In addition, the study included the degree to which teachers report they are successful in using student-to-student discourse and the frequency with which teachers include student-to-student discourse in teaching science. The study has potential significance for three

groups of educational professionals: teachers and curriculum specialists, school administrators including curriculum coordinators and directors, and universities.

For teachers, the study identified the ways others are using student-to-student discourse to increase student learning. It is hoped that the findings of this research will become a useful reference as a compendium of approaches and strategies teachers use and the degree they have found these approaches and strategies to be effective or ineffectual. The study articulated the factors and conditions that elementary teachers of science identified as promoting or inhibiting their use of student-to-student discourse to increase student learning in science. The study may be useful for teachers when working with their principals and colleagues to bring attention to any necessary changes to the current conditions in the school that inhibit the use of student-to-student discourse in science.

For administrators, the study contributed to the growing body of knowledge about the factors and conditions necessary for elementary teachers to implement student-to-student talk in science. The results provided insight into the factors and conditions teachers identify to support them to use student-to-student discourse more effectively. Therefore, this study will help principals better understand how they may create factors and conditions that support teachers in their efforts to use student-to-student discourse in science. It may also help school and curriculum administrators determine and provide professional development opportunities for teachers of science.

The study may be important to universities offering pre-service and in-service teacher education as well as school leadership education. The findings may be useful for pre-service and in-service teacher education programs to develop in teachers an appreciation for this strategy and that they might employ student-to-student discourse in their instructional practice to improve

student learning. Programs for prospective school administrators may find the study useful in providing prospective principals with clear expectations of how to support teacher use of student-to-student talk in classrooms. Thus, there is potential significance to universities that offer teacher training programs, in-service professional development for teachers, and programs for educational leadership.

There may be further significance to other professional university undergraduate and graduate training programs such as those in the science, engineering, and medical fields. Learning to engage in productive discourse with colleagues may have the potential for furthering learning in structures like medical rounds and for collaboration across areas of specialization.

Delimitations

A conscious effort has been made to limit the sample to investigating elementary educators from one school district in the metropolitan area west of Boston, Massachusetts. Therefore, I am not:

- studying the perceptions and classroom practices of middle or high school teachers of science even though there may be transference.
- interviewing students, because the focus in on elementary teachers of science and their efforts to implement student-to-student discourse in the elementary classrooms and in science in particular.
- including school and curriculum administrators even though their perceptions and practices to support elementary teacher may be referenced by teacher participants.
- including families/ parents of elementary students and other key informants.

A second delimitation is the time available for the collection of data. Given time constraints I am not conducting observations of teachers:

- using student-to-student discourse
- interacting with school leaders
- learning in professional development for student-to-student discourse

Although these might further enhance the data collected with rich descriptions, the study focus is on teacher perceptions as self-reported. The instrumentation used self-reporting techniques for collecting data. No correlation to actual progress in student learning was determined in the course of this study.

Review of Literature

The review of the literature served to frame the study. Chapter Two summarizes the bodies of research on discourse for learning and, more specifically, discourse for learning science. There are three sections. The first focused on the value of discourse for students to learn science. The second examined the various approaches educators use to promote the use of discourse as an effective pedagogical strategy for science learning, both in general and in elementary schools. The final section explored the research identifying the factors and conditions that promote and inhibit the use of discourse as an effective pedagogical strategy in elementary science and in science classroom in general.

Value of Discourse

This section explored the literature regarding the value of using discourse for learning science in the elementary classroom. Books, journal articles, dissertations, National Science Standards, National Research Council publications, Federal and State Policy regarding elementary requirements for science for research on the value of discourse for learning science were examined. The research citing the value of discourse for including all students was examined. Researchers included but were not limited to Lee (2005), Gee (1999, 2004; 2012).

Literature on the value of preparing students to be adults with the ability to make informed choices as full participants in their own lives was examined. Researchers included Barnes (1992, 2008) and Cazden (2001, 2008). The research specific to science learning and discourse for students to construct meaning so they comprehend science concepts were also drawn upon; Duschl (2008; 2007), Duschl and Osborne (2002), and Scott (1998).

Approaches to Implementing Discourse

This section addressed the approaches to implementing discourse in two sub sections. First the literature on the role a school leader might use to promote the use of student-to-student discourse by teachers was examined. It included the approaches principals, curriculum coordinators, or directors, and professional developers might use to help teachers implement student-to-student discourse in elementary science (McNeill, Lizotte, Krajcik, & Marx, 2006; Sarah Michaels et al., 2008). The second sub section considered the literatures on the approaches teachers can use to promote the use of student-to-student discourse in the elementary classroom for learning science (McNeill & Krajcik, 2009a; Mercer, 2010; Mercer et al., 2004; Sarah Michaels & O'Connor, 2012; Sarah Michaels et al., 2008).

Approaches to implementing discourse by school leaders.

This section examined the approaches that school leaders: principals, curriculum coordinators or directors, and professional developers might use to help teachers to foster student-to-student discourse in their classrooms. This included research on the role of school leadership as leaders of change such as Sarason (1971), Heifetz (1994), Duffy (2003), Fullan (2005), Wagner and Kegan (2006), Bryk, Sebring, Allensworth, Luppescu, and Easton (2010), and Drago-Severson (2009; 2012). Additional researchers were drawn on regarding coaching literature and literature on change leadership such as Kotter (1996) and Wagner (2006).

Approaches to implementing discourse by elementary teachers.

This section discussed the two major forms of discourse, presentational and exploratory (Barnes, 1992, 2008), each grounded in particular theories of learning, was highlighted. Presentational represents a transmission theory of learning where information is transmitted and the exchange is between the teacher and one student (Cazden, 2001). Exploratory discourse is grounded in constructivism because the students talk with each other to negotiate meaning and co-construct meaning with each other (Barnes, 1992). The role of the teacher in fostering student-to-student discourse in science, developing the skills and dispositions students need to be successful learners of science was examined through the work of Driver, Newton, & Osborne (2000); R. A. Duschl & Osborne (2002) Erduran, Simon, & Osborne, (2004); Mercer (2010; 2009; 1999), Michaels & O'Connor,(2012); Michaels, O'Connor, & Resnick,(2008); Scott, (1998), Harlen (2006), and Cazden (1998). Current and emerging research on the explicit modeling, teaching, and scaffolding for all students to engage in discourse (McNeill & Krajcik, 2009a; McNeill et al., 2006; Sarah Michaels & O'Connor, 2012; Pimentel & McNeill, 2013) were considered.

Necessary factors and conditions for discourse

This section examined the literature on desired conditions and necessary factors for discourse in science including educator beliefs and perceptions because the research offers insight into the necessary conditions and factors identified by teachers and school administrators to increase student-to-student discourse. Literatures in such work by National Research Council (2012), Cazden (2001, 2008), Duschl (2008; 2002; 2007), and Pimentel and McNeill (2013). Literature on setting three conditions necessary: trust Schön (1983), and Edmondson (2012), building professional capacity Barnes (1992, 2008) and Driver, Newton, and Osborne (2000),

Mercer (2010; 2009; 1999), Duschl (2008; 2002; 2007), Drago-Severson (2009; 2012), and curriculum for discourse (Longstreet & Shane, 1993; McDonald, 1999) were examined.

Design of the Study

The discussion of the study design is handled in two sections. The first section explains the general aspects of the design. This section is divided into three subsections: rationale for the choice of design selected, the selection of subjects and setting, and instrumentation. The general features of each are described in each subsection. The second section focuses on the methodology of the research design addressing each of the three research questions individually. The section is divided into two sections: data collection and data analysis.

Rationale for the design selected

This qualitative research study is a phenomenological study. This methodology was chosen because it enables the researcher to arrive at the common themes of a phenomenon by examining the perceptions of people who have experienced that phenomenon. The research focus was on teacher perceptions of their experiences helping students to use student-to-student discourse for learning science. The study collected data through an originally developed on-line survey that was followed by interviews of a subset of teacher respondents. The study did not use observations of teachers because the study is not evaluating teacher practice.

Selection of subjects

Subjects for this research were selected from one school district in the metropolitan area west of Boston, Massachusetts. The selected district had teachers who have participated in professional development using student-to-student discourse as an instructional strategy. All participants were elementary teachers who teach science in addition to other academic disciplines, e.g. English Language Arts, Mathematics, and History/ Social Sciences. As was

expected, there was a range in years of experience teaching elementary science and in the grade levels taught. The survey was sent electronically to 109 subjects, while the interview process included eight individuals selected based on their indication of a willingness to be interviewed on the survey, their responses to specific questions in the survey, and because of their experience with the topic of study, student-to-student discourse.

Instrumentation

Data was gathered utilizing two instrumentation protocols and analysis of artifacts. The first instrument was an on-line survey conducted in one district, distributed electronically to 109 elementary teachers. While the projected response rate of 30-40% was high, and took into account elementary teachers' interest in learning more about student-to student discourse in science, the actual response rate was 23 teachers out of 100 who received the survey, or 23%. The second instrument was an interview of a subset of the elementary teachers surveyed and volunteered to be interviewed. The survey and the interview were designed to address the research questions. All Institutional Review Board protocols determined by the university and individual school districts were followed.

Phase 1: Survey. The survey instrument questions included both closed questions using either Likert scale or a pull-down rating scale. Nine of the eleven questions were designed for teachers to self-report the degree to which they value student-to-student discourse for student science learning, the strategies teachers use to increase student participation in student-to-student discourse, as well as the identification of the conditions that support the instructional practice. Three open-ended questions elicited teachers self-reporting of the definition of student-to-student discourse, the extent of their professional development using student-to-student discourse, and their desire for further training.

Phase 2: Interviews. Individual interviews of eight teachers were designed to be 30 to 45 minutes in length. Each interview was conducted one-to-one, in person, and at the teacher's workplace. The interview protocol was designed with questions to gather more in-depth, anecdotal data to answer the three research questions. It was hoped that teachers would share their experiences using student-to-student discourse, the various instructional strategies they use, as well as identify the factors and conditions that promote or inhibit the use of student-to-student discourse to increase student learning in science. A process of member checking was integrated in the interviews. In this process, the interviewed teachers were consulted on the researcher's interpretation of their data with the opportunity to discuss and clarify the interpretation as well as contribute new or additional information.

Artifacts. Additional artifacts that were collected and examined included teacher plans for science lessons, photographs of charts, or other materials used in instructing students or guiding student-to-student discourse, e.g. charts of norms and sentence starters.

Data Collection Process

In this section, the specific approaches to obtain data for each question are explained. Each of the three guiding research questions and its purpose is explained. Data was collected using the following methods: an on-line survey using Survey Monkey, recording of follow-up interviews, and review and analysis of artifacts. The survey results were collected electronically and downloaded within an Excel spreadsheet. The interview data was collected by audio recording and then transcribed. All data was held in a locked file and a locked hard drive and only accessible by the researcher. Throughout the process, data was collected and analyzed using themes that surface providing information that inform the research questions.

The primary research sought the perceptions of elementary teachers regarding student-to-student discourse as an important means to improve learning in science. To research the question, the following three guiding research questions were used.

1. To what degree do elementary teachers value student-to-student discourse?
2. What are the various ways elementary teachers of science report they are using student-to-student discourse to increase student learning in science?
3. What are the supports and barriers elementary teachers of science identify as promoting and inhibiting their use of student-to-student discourse to increase student learning in science?

The first question was designed to determine the value elementary teachers of science place on student-to-student discourse as an important means to improve students' learning science. To obtain teachers' perceptions of value, specific questions were asked both on the survey and in the interview protocol. The survey questions ask teachers to identify their definition of student-to-student discourse, their valuation of and frequency in which they implement student-to-student discourse as a means to increase student learning. Respondents were prompted to answer survey questions using a Likert scale. In the interview, teachers were asked to explain their definition of student-to-student discourse and the value they place on student-to-student discourse for student science learning.

The second question allowed teachers to self-report their experiences with the various ways they have tried to use or they are using student-to-student discourse to increase student learning in science. To obtain these data, focused questions were included in both the survey and in the interview. The survey questions used a Likert scale for teachers to self-identify their use of strategies and conditions that research studies indicate teachers should use to increase

students' capacity to participate in student-to-student discourse. The interview questions were open ended so that teachers' experiences using student-to-student discourse are individually represented and described.

The purpose of the third question was to elicit data on the supports and barriers teachers identify as promoting or inhibiting the use of student-to-student discourse. To elicit data about the supports and barriers teachers identified in their efforts to use student-to-student discourse. Survey questions asked teachers to reflect on conditions needed to foster the instructional practice, the extent to which professional development has been offered and useful, and their desire for further training. The survey included specific questions regarding teacher identification of the conditions that must be fostered to support the instructional practice, the extent of their professional development for using student-to-student discourse, and their desire for further training. The survey open response and the interview questions solicited data on the factors that support promoting student-to-student discourse and the barriers that teachers identify as existing in their current school conditions.

Analysis of the Data

All data was organized, prepared for analysis and uploaded or directly imported into a Computer Assisted Qualitative Data Analysis Software (CAQDAS), which used a coded access on the researcher's personal computer. The survey data was collected on an on-line survey provider, Survey Monkey. The results contained the responses for both closed and open-ended questions. Although Survey Monkey provides some analysis, the data was downloaded onto an Excel spreadsheet for analysis. The analysis included collapsing the four Likert scales into two for clearer analysis. The interview recordings were transcribed as a word document and uploaded to the CAQDAS, Atlas.ti. Visual materials, i.e. artifacts from participants, were

photographed and uploaded to Atlas.ti. All data was sorted into types by the source of the data; i.e. survey, interview transcript identified by a pseudonym, or artifact 1.

The survey data collected from scaled responses was analyzed using Excel. The responses to the survey open-ended questions yielded opinions that were uploaded into Atlas.ti for analysis. The interview transcripts were read several times to gain an overall sense of the meaning of the data. The use of Atlas.ti enabled the researcher to designate each question and the accompanying responses as a codable field. Codable fields are responses to questions that yield answers to multiple choice, dichotomous questions, or scaled responses. As the data was analyzed, the codes emerged, although some are expected from the literature. Coding is the cornerstone of qualitative data analysis because text is the data. Codes are labels that assign units of meaning to the descriptive information collected in the interview. The researcher created codes from the literature reviewed, i.e. strategies taught to students to engage in student-to-student discourse, value of student-to-student discourse, the barriers teacher identified, or the supports for teachers using this instructional strategy. The codes were applied to all the interviews and survey open response questions. The coded chunks of text or phrases, sentence or paragraphs mentioned by the interviewees were combined together so that the connection between them becomes evident and themes can emerge. The themes emerged as answers to the study's guiding questions. The coding process enabled the researcher to present multiple perspectives supported by quotations and specific evidence. As a phenomenological study, the themes were used to develop a general description (vignette) of the participants' experience from their responses. The survey data analysis and write up of the findings took place concurrently with conducting the interviews. During the analysis, some data was winnowed or disregarded in order to maintain the focus of the study.

Outline of Dissertation Chapters

This study consists of five chapters. Chapter One provides an introduction that includes the problem statement, purpose of the study, definition of terms, guiding research questions to answer the problem, significance of the study and delimitations. Chapter Two provides a comprehensive review of the literature regarding the value of student-to-student discourse, the conditions necessary to foster the instructional strategy and the approaches teachers can use for student-to-student discourse. Chapter Three explains the research design, method for a phenomenological study, and the role of the researcher. In addition, chapter three identifies and explains the processes for participant recruitment, instrumentation development, and methods that were used for data collection and analysis. In Chapter Four, the data collected and the study findings are presented. In Chapter Five, the findings were discussed, then overall conclusions were drawn. An interpretation was made of the results elucidating what was learned from the study using a comparison of the study results and the examined research on student-to-student discourse. This lens was useful in determining if the study findings confirm past information regarding the gap between the research and teacher use of student-to-student discourse or diverge and offer new information. This approach offers new questions for consideration raised from the data and analysis that were not anticipated. These findings are summarized and the implications of the findings were advanced. References of works cited will follow Chapter Five. Appendices follow the references and include participation and informed consent letters, survey/questionnaire and the interview protocol used in the research.

This study lays a foundation for research guiding the work of teachers, educational leadership, pre-service and current teacher professional development providers, and guides future

research on the use of student-to-student discourse for improving student science learning or learning in general.

Summary

This chapter introduced the study by explaining the statement of the problem and the purpose for the study. Specific terms were defined. The study's significance was presented and the delimitations of the study outlined. The organization of the literature reviewed was presented as addressing the value, approaches to implementing discourse, and the necessary factors and conditions for discourse. The design of the study was presented as two phases, a survey and interviews. The methods for data collection and analysis were outlined and discussed. Finally, the chapters for this study were outlined and explained.

CHAPTER TWO: REVIEW OF THE LITERATURE

This literature review explores the gap between what researchers present as good science education instructional practice and what is actually happening in many classrooms. The overall organization of the discussion is in four sections. In the first section, the value of student-to-student discourse in classrooms is advanced. The second section examines the different forms of discourse in connection to different theories of learning. The third section considers the necessary conditions for effective classroom discourse. The fourth section describes the role of the teacher in fostering discourse in the science classroom. Finally, a summary of each section with questions left unanswered by the research is provided.

Introduction

The change in the focus from purely content and skills to the inclusion of discourse is an important shift for instructional practice. There must be a change movement afoot in education when newly adopted national standards, e.g. the Common Cores in Mathematics and English Language Arts, include practices of discourse between students. Further, the National Research Council's Conceptual Framework for new K-12 Science Education Standards and the recently released national Next Generation Science Standards incorporate discourse in the practices of science and engineering. In national and state standards, two other curricular disciplines (English and Math) explicitly incorporate student-to-student discourse, where they once focused on content and skills only. Now science and engineering standards are doing the same (R. Duschl, 2008).

The research finds that discourse in the science classroom has beneficial educational results and thus discourse is included in the standards (R. A. Duschl et al., 2007; Sarah Michaels et al., 2008). Researchers describe effective discourse as purposeful talk between students to

learn complex academic content (Sarah Michaels et al., 2008). Students engage with each other to make sense of new information in relation to their pre-conceived understanding of concepts (Barnes, 1992; Sarah Michaels et al., 2008). Through discourse, students talk to construct meaning so they comprehend science concepts (R. A. Duschl et al., 2007; Sarah Michaels et al., 2008). Purposeful student-to-student discourse fosters conceptual change necessary to comprehend and learn science.

There is a gap between what research reveals as effective instructional practice and what happens in classrooms. Student-to-student discourse is not fostered with consistency in science classrooms (R. A. Duschl et al., 2007). Most curricula and instructional practice observed in classrooms does not reflect the standards that include student-to-student discourse as a pedagogical practice (R. Duschl, 2008; McNeill & Krajcik, 2009b; Pimentel & McNeill, 2013). Teachers are more concerned about the transference of information or "facts" than the process of student learning through discourse (R. Duschl, 2008).

In addition to assisting students improve their understanding of complex science concepts; discourse helps provide equal access to learning for all students. Affording all students with the opportunity to become scientifically literate is an issue of equity (Cazden, 2001; Sarah Michaels et al., 2008). With student-to-student discourse, all students are able to join discussions and to learn rigorous academic content (Sarah Michaels et al., 2008). In turn, all students have the opportunity to learn from each other, to appreciate different viewpoints and cultural perspectives.

A change in teacher instructional practice is required to incorporate discourse in science classrooms. In schools, learning occurs in the dynamic between the teacher, the curriculum and the student in the classroom (Bryk et al., 2010). Instructional practice has the capacity to

establish a classroom culture that enables the learning to occur through discourse (Sarah Michaels et al., 2008). Incorporating discourse in classrooms requires a change in how teachers plan and conduct lessons (Cazden, 2001). Changing instructional practice requires support from school administrators, improved curriculum design, and focused professional development.

While school administrators may ask teachers for more student-to-student discourse, often teachers do not have the training to incorporate discourse and administrators do not necessarily know how to support teachers to make the required change in instructional practice. Schools are systems, so making a change in the culture of teaching and learning requires a clear direction for teachers from school administrators (Lunenburg, 2011). In most cases, teachers have not had the preparation to foster student-to-student discourse. Most pre-service training or professional development does not include the pedagogy of student-to-student discourse (Barnes, 1992; Sarah Michaels et al., 2008). In addition, there is little training for principals that adequately prepares them for helping teachers improve instructional practice. Before expecting substantial change in instructional practice, prospective and current teachers must have the opportunity to learn about and experiment with discourse in the classroom. Further, administrators must have a clear understanding of what constitutes effective discourse in the classroom so they can support teachers in building the professional capacity to incorporate it in their teaching.

Value of Discourse in Science Education

This section explores the literature regarding the value of using discourse in the science classroom: discourse to produce a scientifically literate public that applies scientific knowledge to make effective personal decision-making, to encourage participation in civic affairs, discourse

to increase economic productivity; and discourse to support all students developing critical thinking skills.

The value of discourse for learning emphasizes the importance of language use and social interaction within communities for the development of educated ways of making sense of the world (L. Vygotsky, 1978). Education includes learning specific language and using it to construct knowledge and make sense of the world (Hattie, 2008). Each discipline has its own language and vocabulary; using the language in discourse is an important part of learning that discipline. In simpler terms, learning is a process of induction into an educated culture. Talk is the way people learn from and teach each other. Engaging in discourse offers all students the opportunity to engage with each other to make sense of how the natural world works.

Scientific Literacy

Scientific literacy is the knowledge and understanding of the scientific concepts and the processes of doing science (National Research Council (U.S.), 1996). Implicit in scientific literacy are particular skills and abilities. First is the ability to identify scientific issues that underlie local and national decisions. Second is the ability to evaluate scientific information by considering the reliability of the source of the information and the methodology employed. Third is the capacity to construct and evaluate arguments based on evidence. As consumers, and as citizens, we need to be scientifically literate to think critically in evaluating the legitimacy of scientific claims and make informed decisions about science-based issues.

The influence of science, engineering, and the technologies permeates every aspect of modern life thus, science literacy is essential for every American citizen (McNeill & Krajcik, 2009; National Research Council (U.S.), 2012). A scientifically literate population understands that scientific explanations are supported by using evidence rather than believing in myths. A

scientifically literate population can participate in the economic and democratic agenda of an increasingly interconnected and diverse world (R. A. Duschl et al., 2007; Michaels et al., 2008).

Some policy researchers argue the goal of science education is to channel students into specific Science, Technology Engineering or Mathematics (STEM) careers, producing scientists and other career experts in engineering and the technologies (National Research Council, 2007). This stance focuses on learning historical and current science content knowledge prior to any opportunity for doing science. Science education researchers claim the role of primary and secondary education is to produce an educated population ready to engage in life as critically thinking, problem solving adults (R. Duschl, 2008). The emphasis on content has merit in advancing the needs of industry, but reflects the traditional content-first approach that limits the scientific literacy of the citizenry. The emphasis on engaging in the practices of science educates all students to be scientifically literate through engaging in dialogic processes because it focuses on what we know and how we know it. Producing a scientifically literate population includes preparing students for science and engineering careers.

Learning is a social process (Dewey, 1938/1997) where interactions between people can result in changes in conceptual understanding and thinking. People use language to share ideas, revise their thinking to come to new understanding of concepts or ideas. Education is a social activity aimed at teaching skills, norms and information thereby inducting students into disciplinary thinking, language, and behaviors (Vygotsky, 1962). Children are socialized into the culture they grow up in by using language in social settings at home, in day care, nursery or preschools schools and in other institutions their family associates with (Scott, 1998). In these interactions, children learn language and apply language purposefully (Scott, 1998).

A scientifically literate population does not appear through spontaneous generation, but develops through effective education. Effective science education is more than memorizing science content or following a methodological script. It involves the social aspect of talking with peers to make sense of new information. Science education helps young people explain the natural world around them through evidence-based thinking, rather than through intuition or belief in mythical explanations. The science education process changes a learner's conceptions of how the world works. Research shows that in science, conceptual change begins with the naive or intuited ideas that develop towards scientific ideas through conceptual change (Dewey, 1938/1997; R. Duschl, 2008). Using discourse enables students to surface their intuited ideas, discard them based on evidence, substituting more scientifically literate explanations.

There are many examples of intuited beliefs not based on actual data. One example is the intuited notion held in many cultures for centuries that bad air caused cholera. Once people realized the actual cause of cholera was bacteria they were able to adopt improved sanitation practices. Another example is the idea that day and night is caused by the sun's motion while the earth stands still. Investigation using models and mathematics enabled people to change to a scientific understanding that the cause is the earth's rotation. Through effective education, a scientifically literate population differentiates between science and myth understanding that science is evidence based.

Current research says effective science education should reflect and support what the larger science community does in its practice (National Research Council (U.S.), 2012). Science explains how we think the natural world works using creditable evidence to support our conclusions (McNeill & Krajcik, 2009a). Effective science education allows students to generate evidence-supported explanations to understand the natural world better (R. Duschl, 2008, p.

269). Scientists make claims based on evidence and engage with their peers in debate of alternate explanations (Michaels et al., 2008). Students can as well. One of the ways scientists and students develop their ideas and understandings is through the act of discourse (McNeill et al., 2006; Sarah Michaels et al., 2008). Discourse helps to make ideas visible and accessible to others who are interested (Hattie, 2008). Therefore, in classroom science education, discourse is important for engaging students in the practices of the scientific community. Through discourse, students learn science content and scientific thinking practices.

The democratic ideal of education offers all students equal opportunity to learn and, as a result, better their lives (National Research Council (U.S.), 2012). The purpose of school is to prepare students to be adults with the ability to make informed choices as full participants in their own lives (Barnes, 2008). In a world increasingly reliant on science and on technologies, science education has two purposes. The first is to produce high school graduates who have the capacity and skills to understand that science and engineering permeate every aspect of modern life (National Research Council (U.S.), 2012). The second is to prepare students for further education toward careers in science and engineering fields.

Engaging in discourse promotes continued learning and understanding of the science and engineering that affect the daily lives of adults who have graduated from high school. Discourse in science develops the skills and knowledge of science required to critically analyze and evaluate information in order to make daily decisions (National Research Council (U.S.), 2012). Examples of these daily decisions range from taking vitamins to environmental issues. Medical decisions are an example where developing the capacity to understand and make informed decisions are beneficial. Some people think that the inoculation of young children with the Measles, Mumps, and Rubella vaccine causes autism. This idea is the result of discredited

research. Yet, in Internet circles, this research continues as valid evidence for the claim and subsequent reason not to inoculate. The result is that where once developed countries declared the diseases eradicated, outbreaks began to occur.

By the end of high school graduates should learn enough content and practices of science to "engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives" (National Research Council (U.S.), 2012). Discourse in classrooms offers the opportunity for students to be critical thinkers and to learn content that is foundational to their lives as adults (R. Duschl, 2008).

Science for All Students

Some researchers ground their thinking about the use of effective discourse in theories of democratic education and classroom equity (Cazden, 2001; Sarah Michaels et al., 2008). In order to accomplish the democratic educational ideal of a scientifically literate citizenry, two assumptions are made. First, student-to-student discourse gives every student in the class access to all the ideas and content (Cazden, 2001). Second, discourse provides each student with the opportunity to share her/his ideas, gain the deeper understanding of people's different perspectives, cultures, and ideas, and receive feedback from peers (Sarah Michaels et al., 2008).

Providing all students with the opportunity to become scientifically literate is an issue of equity (Cazden, 2001; Sarah Michaels et al., 2008). If all students are to understand the ideas and content of science so they grow up to be a contributing member of today's world, then it is incumbent on teachers to provide the opportunity for all students. Providing the opportunity is not simply exposing students to the content of science because exposure does not help them make sense of science ideas or concepts. Telling students information only works when students

are ready for what the teacher is telling them. Research tells us that all students come to the classroom with intuited ideas of the natural world works based on prior experiences. Additionally, students come with a variety of experiences that may or may not include interacting with the natural world, practice engaging in discourse, or both. Research shows that the development of oral language and communication skills are shown to compound the disadvantage of lower socio-economic groups (Alexander, 2010). Student-to-student discourse encourages all students to draw on the language they use outside of school, while practicing and improving new discursive tools (Sarah Michaels et al., 2008). Student-to-student discourse includes all voices or perspectives in the classroom while offering the opportunity for all students to develop educated explanations of how the world around us works (R. Duschl, 2008). As a matter of equity, student-to-student discourse offers all students the opportunity to make sense of scientific ideas with their peers. All students have the opportunity to learn the scientific content needed for science literacy to engage in civic debate, or to making one's own decisions (R. A. Duschl et al., 2007).

An inequity exists because not all students have immediate access to the discourses that researchers consider will make learning easier (Hicks, 1995). Students come to school from diverse linguistic, cultural, and socioeconomic backgrounds with already constructed knowledge (Hicks, 1995; Sarah Michaels et al., 2008). They bring to the classroom the discourses or socially shared ways of acting, talking and believing from their home community (James P. Gee, 1999). The discourses from the home-life of students may not be the same as the discourse of the classroom. Sometimes the knowledge from students' cultures may be at odds with western scientific thinking (Lee, 2005). In traditional science classrooms a focus only on western scientific thinking limits access to content because teachers use direct teaching, teacher talk and

text reading (Lee, 2005). Using discourse allows students to use the language of science and engage in making sense of the content and language when their home communities may not offer that opportunity (Driver et al., 2000; Hicks, 1995). Teachers can teach the language, behaviors and habits of mind students need for student-to-student discourse. Through student-to-student discourse, the students are able to clarify between their everyday language and a scientific explanation (Barnes, 2008). Through student-to-student discourse, students are afforded multiple opportunities to access the content and ideas of science because they learn that language of the discipline.

Discourse provides each student with the opportunity to gain a deeper understanding of people's different perspectives, cultures, and ideas, and to receive feedback from peers. Listening to ideas of peers from different cultures or with different perspectives requires consideration of those ideas. Researchers of second language learners note that students move toward scientific theory through their engagement in discourses that seem unscientific because students draw on experiences from outside of the classroom (Ballenger & Carpenter, 2004; R. A. Duschl & Osborne, 2002). Students bring to the classroom their cultural experience and perspective. In student-to-student discourse, these experiences and perspective are included in the content discussion. The result is that the addition of multiple perspectives expands the content beyond a single perspective offered by a text. Students may use different words, expressions, or verb tenses from their home language to convey their ideas. Rather than the language deficits as the focal point, the students' ideas should be paid attention to. Student-to-student talk offers the opportunity to learn from the experiences of English language learners as intellectual resources (Lee, 2005).

When using discourse, students can listen to different ideas respectfully and include each other's ideas in the co-construction of their knowledge. Leach and Scott suggest that students "make sense of the talk which surrounds them, and in doing so, relate it to their existing ideas and ways of thinking" (1995, p. 44). Through the discourse, all students have the opportunity to verbalize their ideas, hear others' perspectives, learn from each other, and offer feedback to each other (Barnes, 1992). On-task conversation enables all students to interact verbally as they wrestle with their ideas, conversing and adding on to the conversation, considering all ideas as they make sense of the evidence. Classrooms where students talk and reason to make sense of scientific explanations of the natural world offer opportunities for all students to access the ideas and content of science (Sarah Michaels et al., 2008; Pimentel & McNeill, 2013).

In summation, there are several values to using discourse in the science classroom. Discourse develops a scientifically literate citizenry in which people think critically about the world around them, solve problems based on available evidence, and evaluate alternative explanations. Such thinking promotes effective decision-making about important life-situations. Further, discourse provides the opportunity for all students to engage equally in the process of learning science through the communication and examination of diverse ideas. Although some students can and do learn science without the use of discourse in the classroom, research has shown that discourse is effective for reaching larger audiences of students and developing 21st century decision-making skills.

Forms of Discourse

This section compares two major forms of discourse; presentational and exploratory (Barnes, 1992, 2008), each grounded in particular theories of learning. The study of classroom discourse is the "study of a communication system" or "a kind of applied linguistics — the study

of situated language use in one social setting" (Cazden, 2001, pp. 2-3). Researchers use linguistic analysis to dissect the discussion to look for patterns in the discourse. Researchers also study who controls classroom language and who has the opportunity to talk (Barnes, 1992). The linguistic patterns, control, and content of the discourse are useful as indicators of the form.

Presentational Form

Presentational discourse is a form most observed in classrooms. Teachers understand the value of talk as a means to transmit ideas and information (Barnes, 1992). Teachers talk and expect students to listen, learn, and recite what they learn or answer teacher questions to show what they learn. Barnes (1992, 2008) notes that teachers tend to invite students to engage in presentational talk. The presentation form of talk is similar to a final draft; a presentation of the student's knowledge is required for display and evaluation (Barnes, 1992).

The pattern of presentational discourse is described as an initiation-response-evaluation (IRE) or an initiation-response-feedback (IRF) exchange (Cazden, 2001). Researchers refer to this model as authoritarian or teacher controlled discourse (Pimentel & McNeill, 2013). In the pattern, the teacher asks a question and calls on a student, the student answers. The teacher evaluates the student's answer by responding in one of two ways; either by rephrasing the student's answer to match the answer the teacher wanted or give the student evaluative feedback on the accuracy of the answer (Cazden, 2001). The teacher's voice always precedes and follows student contributions. The talk is heavily teacher initiated and controlled with the majority of students in the classroom spending most of their time as passive listeners.

The format functions as a means to manage the class and control the content. The classroom is structured so the teacher has control over the talk limiting who talks in the discourse (Barnes, 2008). The classroom discourse is limited to an interaction between the teacher and one

student at a time (Barnes, 2008). Speaking rights and responsibilities are a structure of control in a classroom. "Frequently the teacher chooses the verbal traffic" (Cazden, 2001, p. 82). Barnes refers to the format as "recitation" noting that the interaction in controlling talk "performs the function of managing the class and holding attention" (2008, p. 10). The authoritative discourse maintains the teacher's control of the classroom talk, while offering a few students the opportunity to speak.

The type of questions teachers use and the role of the student in answering are indicators of presentational discourse. Teacher questions tend to be a "display" type of question in which the student displays knowledge or is used as a contributor in an alternate type of lecture format (Cazden, 2001, p. 46). In this format, the teacher only asks questions that have an answer the teacher expects, often answered by a single word. Familiar classroom examples are questions like "what state of matter is ice" or "what group is a butterfly in". With these questions, the student's answer fills in the blank in the teacher's monolog displaying learned knowledge. The expectation is that other students hear a student's answer and learn from the teacher's confirmation or correction of that answer.

The pattern of talk in authoritative discourse reveals the curricula of the classroom. Similar to the lecture format, teacher controlled or authoritative discourse focuses on knowledge as a commodity transferred from the teacher to the students. If the students listen, they should be able to answer the teacher's questions with the right answer. Although there is some student voice, it is a recitation or display of the right answer (R. Duschl, 2008). This form of discourse does not offer the opportunity for students to talk and work out their understanding through talk (Barnes, 1992). Rather, talk is primarily teacher talk, as in the lecture format. Any discourse is

limited to the teacher and one student. The result is that learning is an information transfer from the teacher and the student contribution is to recite correct answers.

Presentational discourse has its roots in the transmission model of learning. The model has proved useful for the development of some types of skills; e.g. rote skills learned through reinforcement and practice. However, evidence has shown that tasks requiring more complex thinking and higher mental processes are generally not well learned through transmission methods alone and require more attention to how people perceive, process, and make sense of what they are experiencing. Presentational discourse, while widely used in classrooms, does not promote student-to-student discourse that has been shown to be so helpful in developing student understanding of science concepts and reasoning skills.

Exploratory Form

Exploratory discourse offers an opportunity for exploring and testing out partially formed ideas with others. Exploratory talk invites student-to-student interaction and provides a chance for learners to revise their thinking through talk or because of talk (Barnes, 1992, 2008). Although the teacher has control of the topic and focus of the discussion, the students talk with each other to explore their thinking then students report to the whole group. The ratio of student talk to teacher talk is greater and the teacher is the facilitator of the student-to-student talk. Exploratory discourse offers an opportunity for students to assist and support each other in making meaning of new learning. The opportunity to share with the whole group has the potential to build the common knowledge of the class through the negotiation of differing ideas in order to come to consensus.

Science educational research shows that students must uncover their intuited ideas before learning new, more scientific ideas that change their thinking (Harlen, 2006). In exploratory talk,

the nature of the discourse enables students to offer partially formed ideas, to test them out, and to see how their thinking aligns with their peers. As students talk with one another, their talk is exploratory rather than a presentational (Barnes, 1992). Students can engage in meaning making though by rethinking their ideas through discourse with each other (Barnes, 1992).

Each of us learns by sense-making as we actively construct mental models of the world (Barnes, 2008). We test out these models in experimentation and through discourse with peers. In the process, we can reshape our models, and potentially reshape how we experience some aspect of the world and then how we act on it.

Let us consider how effective student-to-student discourse works in a classroom example where second grade students in a mixed socio-economic classroom test their ideas of the Earth's rotation using a simple model of a globe and the sunlight through the window. As the students turned the globe, the cause of day and night became apparent: the earth rotates; the sun does not revolve around the earth. Student conversation reflected this new understanding asking why our language uses words like sunrise and sunset when everyday language does not reflect what actually happens (Craddock, 2005). Were students asked only to present their ideas in response to the teacher's questions, all students would not have heard and clarified the confusion between the scientific understanding that the earth turns so we see day and night and everyday language that suggests the sun revolves around the earth.

Lessons using exploratory talk typically are ones with minimal teacher talk but a great deal of student talk. Student groupings vary as dyads, triads, quartets, or even quintets. Often the teacher initiates the discussion with a question or focus for the discussion. Students work to answer the question or to make sense of a hands-on investigation. Students' contributions in the discussion follow each other and may include teacher input. Using the notation of initiation-

response-evaluation or initiation-response feedback (IRE or IRF) of presentational talk, exploratory talk has more of an I-R-R-R-R-E/F pattern (Cazden, 2001). Here, several student responses follow the teacher's initiation, with the teacher giving evaluation or feedback after several responses. Routines like turn-and-talk and think-pair-share, or small group work discussion are typical of this form. However, recent research includes large group discussion as exploratory discourse. Here the talk enables the group to come to a consensus around a concept.

Exploratory discourse is grounded in constructivism because the students talk with each other to negotiate meaning and co-construct meaning with each other (Barnes, 1992). The teacher's task is to set up situations that challenge students' current understanding so students will connect new ideas to existing ones and in the process, modify their ideas (Barnes, 2008). Student-to-student discourse plays an important role in the development of mental processes (Wertsch, 1988, 2008). Students take an active role in the construction of knowledge through their engagement in talk with each other to exchange and try out their ideas while learning the process of reasoned participation in academic discourse (Sarah Michaels et al., 2008). Students simultaneously build their conceptual understanding of subject matter and build their capacity to engage in productive academic discourse.

In comparing the two forms of talk in classrooms, it is clear that, although different, both forms of talk have a role in student learning. While both forms of discourse have a use in the classroom, the art of teaching is in matching the discourse form with the task. Presentational discourse is effective where rote learning and specific skills are required. By contrast, effective exploratory student-to-student discourse promotes the development of critical thinking and problem solving. Teachers need to be sensitive to the differences between presentational and exploratory talk in order to use each appropriately (Barnes, 2008; Cazden, 2001).

Conditions Necessary for Discourse

Fostering increased student-to-student discourse depends on the conditions within the school. Foundational to implementing discourse is the belief that all students can participate and contribute to classroom science discourse with increasing independence (Sarah Michaels et al., 2008). Students can develop a deep understanding of the science concepts and develop the ability to learn with increasing independence (McNeill et al., 2006). All students have something to contribute and to learn from well-structured discussions. Research finds teachers' beliefs about their students' capacity to engage in discourse encourages or prevents the use of student-to-student discourse (Sarah Michaels et al., 2008; Pimentel & McNeill, 2013). The belief that all students can engage in discourse is essential if teachers are to include discourse as instructional practice.

To use discourse effectively, teachers and school administrators must believe that all students can participate in effective discourse, understand, and create the conditions to support the instructional practice. There are three conditions necessary. First, teachers and school administrators must establish a culture of trust (Bryk et al., 2010; Schön, 1983). Second, the staff must have the professional capacity to include discourse effectively (Bryk et al., 2010). Third, the curriculum must include discourse as a tool for student learning (Pimentel & McNeill, 2013).

Culture of Trust

A culture of trust is fundamental for the effective inclusion of student-to-student discourse in classrooms. Trust is relational, established in the social exchanges between staff and administrators. Administrators and school staff work in a dependent relationship to achieve desired outcomes for students. Constant interactions necessitate a continual process of

interpreting each other's intentions and vulnerabilities. Trust is essential for day-to-day administrator/teacher exchanges to be productive, fostering a climate where the adults reflect and collaborate to improve instructional practice (Schön, 1983).

Relational trust is built in the areas of social respect, personal regard, discernments about role competence, and perceptions of personal integrity (Bryk et al., 2010). Built in everyday social interactions, relational trust is grounded in social respect where all ideas are heard and thoughtfully considered (Bryk et al., 2010). Personal regard develops in social exchanges leading to a sense that others care. Working in collaboration, the adults build a regard for each other's integrity, reliability, and capacity to follow through on commitments to work toward desired outcomes. The relational trust between the adults of the school reflects and influences the relational trust in the classroom.

Relational trust must exist for teachers to feel safe so that they can change their instructional practice, experimenting as they move from explicit teaching of science as information to include student-to-student discourse. Similarly, in order for students to feel they can openly share their thinking and have something to contribute, trust between members of the classroom community must exist within the classroom. Research shows the development of relational trust in schools is fundamental to intra-staff interactions and staff interactions with students to support continuous improvement in instructional practices.

Professional Capacity

Professional capacity is the combination of beliefs, skills, attitudes, and work arrangements that allow school administrators and skillful staff to form a viable collective that shares responsibility and supports continuous improvement (Bryk et al., 2010). In this case,

professional capacity refers to the staff's commitment to and skill in implementing student-to-student discourse.

Administrators have a large role in developing the professional capacity in school. School administrators need to know the value of student-to-student discourse, the conditions supporting discourse, and the characteristics of effective discourse. If administrators know the value of student-to-student discourse for student learning, they will prioritize the use of the instructional practice. Then, as instructional leaders, they can foster the conditions to support discourse. Administrators can guide and support teachers to include student-to-student discourse as an instructional pedagogy. Further, they can structure opportunities for teachers to read research articles or books based on research on the instructional practice. Additionally, as evaluators of teachers' instructional practice, administrators can give teachers direct feedback to include student-to-student discourse as instructional practice. The unique position of school administrators is instrumental to developing the professional capacity of teachers to include the instructional practice of student-to-students discourse.

Teachers' professional capacity means that they have a deep understanding of the science concepts that they are teaching and possess the skills to include student-to-student discourse in their classrooms (R. Duschl, 2008). Deep understanding of concepts gives teachers the confidence to allow for discussions (Barnes, 1992). Teachers who understand the content and concepts they teach steer students' discussions when they go off topic and intervene when students rely on intuited conceptions (Sarah Michaels et al., 2008). Further, teachers can recognize when misconceptions are "stepping stones" as they move towards a more scientific one (Campbell, Schwarz, & Windschitl, 2016). As formative assessment, teacher use these stepping stones to guide students to their next steps towards a scientific explanation. In the

earlier example of the discussion of the motion of the earth causing the pattern of day and night, the teacher's understanding of the content enabled correction of the students' intuited, non-scientific conceptions. When teachers have a solid conceptual understanding, then teaching is providing the opportunity for students to examine their thinking and change their conceptions, rather than an exercise in telling students information.

Teachers and school administrators must understand and implement instructional strategies to support student-to-student discourse. A culture of relational trust built between the school staff and school administrators fosters the conditions to build capacity and model the trust expected between students in discourse. It is incumbent on the school administrators to create the climate and conditions so that teachers can build professional capacity. School administrators can ask for changes in instructional practice and offer professional development for teachers to foster student-to-student discourse. However, teachers are responsible to develop their capacity to make changes in their instructional practice.

Curriculum for Discourse

Student-to-student discourse requires curriculum that is transparent in content and in its mandate to employ particular skills for students to learn content. Curriculum is the instructional guidance sub-system in school systems. While curriculum is frequently considered as the "allocation of resources to teaching and learning based on some set of values" and the resources are "time, space, teaching expertise and teaching materials" (McDonald, 1999, p. 14) there are other perspectives. Curriculum scholars hold that schools have four curriculums, the explicit, implicit, null, and extra or co-curriculum. The explicit or obvious curriculum is the subjects taught, the knowledge and skills students are expected to acquire. The implicit or hidden curriculum arises from the behaviors, attitudes, and expectations that characterize the school's

culture (Longstreet & Shane, 1993). The null curriculum refers to the topics or perspectives specifically excluded from the explicit and implicit curriculum (Eisner, 1994), while the extra or co-curriculum is the extra-curricular, school-sponsored programs intended to supplement the academics.

In this case, the teachers must take into consideration the explicit and implicit curricula to include student-to-student discourse effectively. The explicit curriculum must direct why and where to include discourse effectively. Explicit curriculum makes clear to teachers the scope of the year's content, materials, and use of specific instructional strategies so that students learn the practices, skills, and content of a particular discipline. Implicit curriculum conveys the values of the school and of the teacher and thus the classroom. If teachers realize both the explicit curriculum and the implicit curriculum do not mandate the use of discourse, then they will not use it. Teachers need clearly constructed explicit curriculum to know the expected instructional methodology to teach content. Further, teachers need a heightened awareness of the communicated implicit curriculum so student-to-student discourse is an opportunity for all students to have their perspectives and ideas heard and considered. Transparent explicit curriculum clearly outlines the academic purpose for student-to-student discourse matched with the appropriate talk format. Implicit curriculum clearly communicates the value of student-to-student discourse as a tool for learning.

Assessing Discourse for Learning

Formative assessment is a recursive process between students and teachers that provides information to inform teaching and learning as it is happening. Teachers use formative assessment to inform and then adjust their teaching. Formative assessment can be "substantive" when teachers focus on continuously attending to students' thinking, reasoning, and participation

in order to improve learning (Black & Wiliam, 1998). Students reveal their conceptual understanding and their ways of reasoning about phenomena in their explanations. Teachers employ these explanations as the basis for effective instructional decisions.

A wide variety of methods can be used by teachers to conduct in-process evaluations of student progress and learning needs through a lesson or unit. Formative assessment has the potential to positively impact students' learning through discourse (Black & Wiliam, 1998). Student-to-student discourse can tell the teacher much about student learning and understanding of science concepts. Discussions with peers allow students to increase the breadth and depth of their understanding while discarding erroneous information and expanding and explaining background knowledge (Black and Wiliam 1998). Important in this process are allowing time for students to think through their ideas, and all students have time to express their ideas. This way, students' ideas and reasoning can be resources for both the class and teachers to draw on as resources for teaching and learning (Windschitl, 2013).

Most often the discourse in classrooms is a question and answer pattern between the teacher and students. Discourse as a dialogue between the teacher and an individual student was previously discussed in the section on two types of discourse as presentational discourse (Barnes, 1992). The teacher asks a question, then assesses, responds either confirming or correcting the student's answer. Often, the teacher corrects by restating and modifying the student's answer or directing the student to the expected answer (Cazden, 2001). While the intent is to formatively assess and give feedback to the students, an unintended consequence is that students receive the message that they are not required to think critically to puzzle out their own answers. Rather they learn to figure out what answer the teacher is looking for (Black & Wiliam, 1998).

Teachers must know how to effectively assess student discourse in order to know what to teach and model. Teachers utilize students' past experiences to figure out the thinking going on behind a student's idea (Braaten & Windschitl, 2011). The teacher then makes a conjecture of what the student is thinking, and responds to address the student's misunderstanding. The ability to determine if an explanation is scientific is dependent on the teachers' knowledge of scientific explanation and content. Most elementary teachers often have little or no science content background so evaluating science explanation is challenging (Braaten & Windschitl, 2011). Building teacher capacity in science content explanations is necessary for both pre-service and in-service teachers. Teachers need to develop their capacity to know when to "step in" to students' discussion to redirect and then to "step out" so students struggle with peer to explain their evolving science ideas. In this way, student-to-student discourse can be used similarly to formative assessment (Alexander, 2004; Mercer et al., 2009). Teacher understanding and effective use of formative assessment is integral to student-to-student discourse for furthering student science learning.

School administrators can positively affect teachers' implementation of formative assessment. Sometimes, teachers' perceptions about their formative assessment practice and what is considered effective formative assessment is mismatched (Ateh, 2015). Several recent studies have shown that school administrators' role as learning leaders was critical to the implementation of formative assessment in their buildings. The principals understood formative assessment, so their classroom observations and feedback focused on "what students are actually doing to develop and produce evidence of their understanding of essential learning targets" (Moss, Brookhart, & Long, 2013). The result was that teachers' formative assessment practice improved as did student achievement. Effective implementation depends on a collaborative

effort by both teachers and administrators who understand formative assessment and "develop the learning-focused assessment culture that raises student achievement and improves instructional practices" (Moss et al., 2013). So, school administrators have the potential to positively effect teacher use of student-to-student discourse as formative assessment.

In sum, the use of discourse requires that educators believe that all students can learn to engage with each other. Teachers can teach students the skills and language necessary to participate in academic discourse, offering support as students move towards independence. Additionally, teachers need to deepen and broaden their subject matter knowledge to foster student-to-student discourse comfortably and capably. Explicit curricula mandating the use of discourse and implicit curriculum valuing the use of discourse is necessary for teachers to utilize student-to-student discourse effectively. Finally, teachers and school administrators must know how to effectively implement student-to-student discourse as formative assessment in order to foster a culture of continuous learning focused on improving instructional practice and student learning in science.

Teacher Role in Fostering Discourse

The role of the teacher in fostering student-to-student discourse is crucial to developing the skills and the dispositions students will need to be successful learners in the science classroom. Those skills and dispositions need to be explicitly modeled, taught, and scaffolded for all students to engage in discourse (McNeill et al., 2006). Teachers have four broad sets of responsibilities to help students become effective users of discourse: (1) set norms for class behavior; (2) teach specific skills of discourse; (3) formative assessment of student discourse, and (4) match the discussion type with the content taught (Sarah Michaels et al., 2008; Pimentel

& McNeill, 2013). All four weave together in the establishment of a classroom culture that values and includes student-to-student discourse for learning.

Setting Norms

The setting of norms, ground rules, or guidelines for class behavior and responsibilities is foundational to student-to-student discourse (Sarah Michaels et al., 2008). The teacher's role is to ensure the establishment of norms for student-to-student discussion. Norms of classroom participation are ground rules agreed upon by the class within which the discussion operates. The joint process creates more ownership by the classroom community. Research shows that well-established ground rules or norms for discussion participation and behavior provide a safe environment for all students to participate (Barnes, 2008; Sarah Michaels et al., 2008). As an agreement, norms offer predictability for behavior in the discussion and infer possible consequences when broken. Classroom norms establish a trust where the discussion is safe for all students to participate.

Although norm development and agreement with those norms occur at the start of the year, reinforcement must happen before each discussion (Barnes, 2008; Sarah Michaels et al., 2008). Thus, the teacher's role is to remind students of the norms before each discussion, reinforcing the class' agreement about behavior and responsibilities throughout the year.

Teaching and Modeling

The teacher's role is to help students be thinkers and defenders of their ideas. Teachers need a generic set of language phrases to model and teach the skills, structures and procedures of academic discourse (Chapin, O'Connor, & Anderson, 2003; Sarah Michaels et al., 2008). Teachers must know how to teach and model the language of academic discourse so that students learn to use the language and behaviors in their discussion with peers.

A core practice of constructing scientific explanations is that a claim is supported by evidence taken from the collected data (Driver et al., 2000; R. Duschl, 2008; Erduran et al., 2004). Using an instructional framework to break down scientific discourse into its four component parts (claim, evidence, reasoning, and rebuttal) helps students understand and eventually use the skills of science discourse (McNeill, 2009; McNeill et al., 2006). Research shows that teachers' explicit teaching and modeling the four component parts of scientific explanation through focus lessons is effective for students (McNeill et al., 2006). Thus, teachers must explicitly teach students the four component parts of scientific explanation.

The teacher's role is to develop students' ability to question both their own ideas and those of their peers (Barnes, 2008). In student-to-student discussions, teachers' questions can further students' science understanding and teach students to use effective questioning. The research shows the type of questions commonly found are ones that ask for clarity, restate other's ideas, and suggest consideration of another perspective (Sarah Michaels et al., 2008). Michaels and O'Connor describe nine generic talk moves (Appendix A) or questions to help students extend and deepen their thinking. Each discourse goal promotes a different kind of behavior: to share, expand, clarify; to listen to others; to deepen one's reasoning; to think with others (Sarah Michaels & O'Connor, 2012). Teaching and modeling these four discourse goals ensures that students will make effective use of them in their own discourse.

Matching Appropriate Talk Type with the Academic Content and Purpose

To ensure effective discourse, teachers match the type of talk to the academic content. The teacher's responsibility is ensuring that the discussion is accountable to the discipline. Research shows that effective matching of the talk type with the purpose of the discussion is dependent on the content knowledge of the teacher (Sarah Michaels et al., 2008). Discipline

knowledge is essential to effective teaching. Therefore, discipline knowledge is essential for teachers so they know the necessary criteria to match talk with the academic purpose resulting in student learning.

Michaels, O'Connor, and Resnick's research on discourse establishes three dimensions of purposeful talk that outline effective student-to-student discourse. Effective discourse is accountable to the community, to the knowledge of the discipline, and to the reasoning of the discipline (Sarah Michaels et al., 2008). As a community, discourse participants listen carefully to each other, ask questions to clarify or expand ideas, and build ideas in response to each other; thus, discussion participants are accountable to one another. Students use correct facts and information to challenge each other for evidence or examine evidence for veracity, so the discussion is accountable to knowledge and the reasoning of the discipline. These three dimensions hold the class accountable for content knowledge and for reasoned discussion. The teacher's role is to ensure that the discussion is true to these three dimensions.

Teachers are responsible for matching the type of discussion with the academic purpose. Michaels and O'Connor propose four types of discussions that match academic purpose in science (Sarah Michaels & O'Connor, 2012). Each type of discussion matches a different stage in a science investigation. An *elicitation discussion* uncovers students' initial ideas before teaching or engaging with materials in an investigation, and serves as a formative assessment (Harlen, 2006). The *consolidation discussion* reinforces the steps in the investigation in terms of scientific concepts and principles rather than intuited ideas (Sarah Michaels & O'Connor, 2012; Sarah Michaels et al., 2008). The *data discussion* allows students to use the data they generated for comparison and analysis. In an *explanation discussion*, students explain their new understandings to each other and negotiate their understanding of the science concepts and

principles as they build common knowledge. Each of the four discussion types matches a science investigation stage, helping students to make sense of new ideas.

In sum, the teacher's responsibility to promote student-to-student discourse is threefold. First, together with students the teacher creates safe context for the discussion by setting and reinforcing norms of behavior in discussion. Second, the teacher teaches and models specific vocabulary and types of questions to assist students in formulating and communicating their ideas. Finally, the teacher purposefully matches the discussion type with the academic purpose to promote making sense of new information. The teacher is crucial to students' growth as effective contributors in science discourse.

Summary

All students gain knowledge and benefit from the process of learning science through the communication and examination of diverse ideas and developing 21st century decision-making skills. Discourse is the purposeful talk between students to learn complex academic content. Typically, classroom discourse is either presentational or exploratory; the former is a testing mechanism between the teacher and a student, while the latter is an opportunity for students to build new knowledge. Research has shown that discourse is effective for reaching larger audiences of students by providing the opportunity for all students to engage equally in the process of learning science. Discourse has value in developing a scientifically literate citizenry in which people think critically about the world around them, solve problems based on available evidence, and evaluate alternative explanations.

Teachers and school administrators enact the conditions for instructional practice that include student-to-student discourse. A culture of relational trust between the school staff and administrators fosters the conditions to build the professional capacity of teachers. Additionally,

an explicit curriculum should make transparent the match between the discussion form and the focus of the discussion. Implicit curriculum, because it conveys the values of the school and of the teacher, should clearly communicate the value of student-to-student discourse and the inclusion of all students and their perspectives.

Clearly, the role of the teacher is crucial in teaching, modeling and scaffolding discourse so that all students can participate. The teacher creates a safe context for the discussion, teaches and models specific vocabulary and types of questions to assist students in formulating and communicating their ideas, and purposefully matches the discussion focus with the science investigation stages to promote making sense of new information. Building teachers' professional capacity is vital to the inclusion of student-to-student discourse in the science classroom.

While there is a growing body of research that supports student-to-student discourse in science classrooms, we rarely see teachers using the instructional strategy. There are multiple reasons to explain why discourse is not used more frequently in classrooms. Teachers identify their knowledge and ability as factors limiting talk in their classroom. Teacher's level of comfort with their science knowledge tends to translate to surface knowledge in science. Often teachers fear not having answers to questions or strong enough skills in scientific discourse. In addition, teachers' perceptions of their students' lack of experience, content knowledge, and motivation limits holding discussions. Teachers often have a constrained view of what constitutes curriculum focusing only on the explicit curriculum. Therefore, teachers see their role as delivering information to students rather than engaging students in making meaning of new ideas, facilitating the discourse among students and teachers.

The research provides copious data to support the efficacy of student discourse. We know what good practice looks like among teachers who use student-to student-discourse as well as the issues when teachers can and cannot do it. Without effective discourse for learning, all students do not have the opportunity to learn to be scientifically literate. All students do not have the opportunity to know how to be critical and creative problem solvers. Absence of effective use of discourse as a pedagogical strategy inadequately prepares all students for work and life in a 21st century, democratic society. Increasing teacher capacity to include student-to-student discourse in science is dependent on professional development in both content and the instructional practice to foster student-to-student discourse.

If student-to-student discourse plays a central role in science and in learning about science, then its current omission is a problem that needs to be addressed. The absence of opportunities to learn to use discourse as an effective pedagogical strategy leaves educators without the tools to teach students effectively in science. If this pattern is to change, then it seems crucial that any intervention should pay attention not only to ways of enhancing the discussion skills of young people, but also to improving teachers' knowledge, awareness, and competence for utilizing student-to-student discourse in their instructional practice and competence in managing student participation in discussion.

CHAPTER THREE: RESEARCH DESIGN AND METHODS

The purpose of this study was to examine the perceptions of elementary teachers regarding the factors and conditions they believe promote and inhibit their efforts to use student-to-student discourse in the science classroom. The study sought to explore the accounts of elementary teachers who have had professional development in the instructional strategy of student-to-student discourse to gain a deeper understanding of the supports and barriers in using student-to-student discourse.

The following three questions guided this phenomenological study.

1. To what degree do elementary teachers value student-to-student discourse?
2. What are the various ways elementary teachers of science report they are using student-to-student discourse to increase student learning in science?
3. What are the supports and barriers elementary teachers of science identify as promoting and inhibiting their use of student-to-student discourse to increase student learning in science?

This chapter discusses the design of the study explaining the general aspects of the design including research methods and procedures, site and sample selection, and explains the role of the researcher. In addition, this chapter identifies and explains the processes for participant recruitment, instrumentation development and the methods for data collection and data analysis.

Research Method Rationale

The research focus and questions guide the choice of research methodology. This qualitative study used a phenomenological approach to investigate the experiences of elementary teachers who have had professional development in implementing the instructional strategy of student-to-student discourse for learning science. Qualitative research is appropriate when there

is little information on the topic and the researcher does not know what to expect (Creswell, 2007). While there is a substantial body of literature on what teachers should be doing to include student-to-student discourse, teachers' perceptions of the supports and barriers to using student-to-student discourse as instructional practice for learning science have not been explored in-depth. Therefore, a qualitative study methodology was warranted.

Phenomenological study design enables the researcher to develop a deeper understanding of a phenomenon through the specific human experience or "lived experience" of the phenomenon than a quantitative survey (Creswell, 2014). The reality of a phenomenon is only perceived within the meaning of the experience of an individual (Creswell, 2007). The ability to understand a phenomenon is through research of people's reports of their conscious experiences. A phenomenological inquiry builds an essential understanding of the meaning, beliefs, and behaviors people have constructed to make sense of their experiences and thus their world. There are strong connections between phenomenological research and constructivism (Armezzani & Chiari, 2014; Chiari & Nunzio, 1996). According to van Manen (2007), phenomenology of practice operates in the space of the formative relations between how we think or feel and how we act. So, a phenomenological study is a means to see the connections between teachers' beliefs or perceptions and their acts to implement student-to-student discourse.

In order to understand the gap between the research and teacher practice, it is important to understand the beliefs and meaning teachers' attribute to the phenomenon (using student-to-student discourse). Therefore, a phenomenological approach was used because the purpose of this study is to understand the perceptions of elementary teachers, how they think or feel, with their actions regarding student-to-student discourse for learning science.

Participants and Setting

This study was carried out in a moderate sized a district that kept the study manageable yet contained diversity. The district chosen was a regional school district serving two suburban towns in the greater metropolitan area of a large New England city. The combined population of the towns is about 27,000. The district serves nearly 5,400 students of which 2,600 are in the six elementary schools and the remainder is the middle and high schools. The six elementary schools offered a large enough population of teachers to complete the survey and subsequent interviews than a smaller system would.

Diversity in the classroom was important because teachers should address learning for all students. Therefore, the district was chosen for diversity in the student population in ethnicity, English Language Learner population, and special education. According to the Massachusetts Department of Elementary and Secondary Education data (Massachusetts, 2014-2015), the student population ethnicity is 61.3 % white, 29.4% Asian, 8.7% African American, 3.3% Hispanic, and 3.7% multi-race, non-Hispanic. In addition, students with a first language that is not English comprise 15% of the population, although only 3.6% are identified as English Language Learners. Additionally, students with disabilities comprise 17% of the population. The diversity of the student body in the district offered the range of student needs in the classrooms and created the need for instruction that would include all students.

The study design necessitated a district where teachers were engaged in on-going professional development. Again, the size of the district resulted in an infrastructure offering in-district on-going professional development. The school district website information notes that the staff continuously pursues professional development. The Massachusetts DESE data indicate that nearly 100% of the teachers are highly qualified, which means they have the proper

certification for the position they are hired to fulfill. This study utilized purposeful selection of participants based on their experiences implementing student-to-student discourse for learning science. The participants were elementary teachers of Kindergarten through grade five who have participated in some professional development in implementing student-to-student science discourse for learning science.

The study focus was at the elementary school level. Purposeful selection was an appropriate method for selecting participants for a study using phenomenological approach because the aim of the study was to understand and describe the phenomenon from the perspective of those who have experiences it (Creswell, 2007). All participants were elementary teachers who taught science in addition to other academic disciplines, e.g. English Language Arts, Mathematics, and History/ Social Sciences. As expected, there was a range in years of experience teaching elementary science and in the grade levels taught.

Participants were recruited for two tasks: (1) to complete an online survey and (2) to be interviewed as a follow-up to survey completion. Survey respondents were recruited through an initial emailed letter introducing the study and included a link to an originally developed on-line survey. This was emailed to 109 elementary teachers of grades Kindergarten through grade five in a single school district (Appendix A). Additionally, the district elementary science specialist sent a supportive email message to all the teachers, encouraging teachers to respond to the survey and reminding that participation was voluntary. Fourteen respondents provided answers to the initial survey request. A second survey request was sent out two weeks after the first request to obtain additional responses. Nine additional participant responses were obtained in this second request. A total of twenty-three teachers responded to the survey. The second task was an interview. The emailed letter inviting participation in the survey apprised potential participants

of the opportunity for voluntary interviews at the end of the survey. At the end of the survey participants provided their contact information to volunteer for interviews.

All participants were informed of the study focus, methods, and the steps taken to maintain anonymity. The first page of the on-line survey included a required check box for participants to agree to participate in the survey. The interviewees were provided with an informed consent statement to read and sign prior to the face-to-face interview, included in Appendix C. All participants were assigned pseudonyms to protect their identities and no personally identifying information is reported. Additionally, all Human Subjects Research and Internal Review Board requirements were met at both the University and at the district.

Overview of the Research Design

The purpose of a phenomenological study is to reduce individual experiences with a phenomenon to a description of the "universal essence" (Creswell, 2007). Van Manen's phenomenology of practice focuses on the relationship between how we think or feel and how we act (van Manen, 2007). This study sought to explore the accounts of elementary teachers who had professional development in the instructional strategy of student-to-student discourse to gain a deeper understanding of their experiences fostering this instructional strategy and with the supports and barriers in using student-to-student discourse.

Phenomenological methods require three steps to investigate and make meaning of experiences: (1) researcher's role, (2) data collection, and (3) analysis of the data. The researcher's role required an examination and disclosure of the experiences and feelings with the phenomenon and employment of a technique of phenomenological epoché or bracketing. Bracketing is systematic procedure that involves systematic steps to "set aside" various assumptions and beliefs about a phenomenon in order to examine how the phenomenon presents

itself in the world of the participant (Creswell, 2007; Moustakas, 1994). The purpose is essential to avoid judgment and biases during research (Moustakas, 1994). Second, the data collection included the participants' perceptions and feelings of the phenomenon, (Moustakas, 1994). Third, the essence of the participants' experiences are deduced (Moustakas, 1994). The methodology is conducted in stages consistent with phenomenological research process (Creswell, 2014).

Qualitative research proceeds as a non-linear, iterative process that proceeds simultaneously with other parts of the developing study. As study data are available, data analysis begins, so both collection and analysis continued simultaneously. Although the process presented here appears linear in form, (1) survey, (2) interview, (3) analysis; the process is cyclical with the data continuing to inform each stage in the process. Through these steps the phenomena and the meanings of the research were recorded and analyzed simultaneously. The systematic collection and analysis of the participants' experiences and feelings and making meaning through discourse leads to the construction of knowledge.

Role of the Researcher

The phenomenon of utilizing student-to-student discourse for learning science in elementary schools, as with any other phenomenological study, can be obscured from researchers by their currently held beliefs about the phenomenon. Over time, personal experiences, professional literature, and training merge to form the researcher's understanding of the phenomenon. Bias influences a study when the research makes assumptions of homogeneity, attribution of a characteristic to a group, and assumptions of causality of particular actions (Pollock, 2008). It is essential for the researcher to be aware of potential biases and to recognize that totally excluding their own bias is challenging. Unlike the role of a quantitative researcher,

the qualitative researcher's role is participatory (Moustakas, 1994). So, it is essential that the qualitative researcher has had experience with the phenomenon so that the researchers' and the participants' experiences can connect and all descriptions of the phenomenon depict the same experience from different perspectives (Moustakas, 1994). Researcher practice of phenomenological epoché or bracketing is foundational in a phenomenological study.

The two steps were taken to examine researcher bias. As the researcher, the first step was an examination of my experiences with student-to-student discourse. The second was analysis of the assumptions and values held that underlie using discourse as an effective instructional strategy. All perspectives are bounded by personal experiences and supported by the assumptions that underlie the reasoning for feelings regarding those experiences. Therefore, bracketing required the researcher to identify assumptions taken as universal truths but were "crafted by your own unique identity and experiences in the world" (Takacs, 2003). Prior to collecting data, personal experiences were described in order to increase awareness of underlying feelings about the research topic.

As a former elementary teacher of science and in my current position as a Kindergarten through Grade Eight curriculum coordinator of science, my experience confirmed the value of student-to-student discourse in science as an important instructional practice because it helps students to develop critical thinking and problem solving skills as well as acquire the knowledge of science. The focus of student-to-student discourse is on student thinking rather than on learning a set of facts. As a classroom teacher, student-to-student discourse empowered students to think critically as they processed and made sense of new information. Leveraging discourse with their peers enabled students to think together and develop ideas together. Discourse with peers also taught students the norms for academic discourse. My assumption was that other

teachers know how to implement student-to-student discourse to further student science learning. As a coordinator, I found this not to be the case and was curious as to why.

As an observer and evaluator of new teachers, I have observed elementary teachers lecturing, explaining, and telling science information to students. I have rarely observed teachers using student–to–student discourse in their instructional practice so students can process and make sense of science ideas and information. While researchers have identified that best teaching practice in science is that of student-to-student discourse to develop a scientific understanding of the natural world, teachers rarely utilize this powerful practice (R. Duschl, 2008). While I have read about and practiced student-to-student discourse, my understanding does not represent a complete comprehension of the meaning of the phenomenon.

My experience with student-to-student discourse influenced my interest in this study and brought challenges as well. Throughout this study, I sought to maintain a stance of inquiry, restrain my own experiences, assumptions, and beliefs in order to understand participant accounts with a "fresh perspective" (Creswell, 2007). However, though I work to control for bias, my own experience and beliefs may influence the study.

Instrumentation

Planning the best means to study teachers' experiences with the phenomenon using student-to-student discourse to improve science learning in schools was based on the work of Creswell (2007) and Bloomberg and Volpe (2012). The information needed to answer the three guiding research questions fell into three categories: (1) beliefs, (2) experiences, and (3) theoretical. This information included:

- Teachers' perceptions regarding the value, instructional strategies for student-to-student discourse to improve student science learning, and conditions to foster the instructional

practice. These included definitions of student-to-student discourse, use of student discourse, the extent to which professional development has been offered and useful, their desire for further training, curriculum guides, leadership support, peer support, time on learning for science.

- Demographic information including: years teaching, years teaching science.
- Continuous review of the literature providing the study's theoretical foundation.

The decision was to use a survey first to poll teachers on their opinions and perceptions regarding the value, instructional strategies, and conditions to foster the instructional practice. This was intended to be the first step in distilling the essence of the teachers' experiences with the phenomenon. The survey went through five iterations before it was sent to teachers in the study. The first two versions were commented on by the senior advisor and reworked, the third version was commented on by all committee members and revised, the fourth revision was based on feedback from a pilot with five teachers and two PhD candidates' comments, and the fifth revision was readied for dissemination. The on-line survey was disseminated using a Survey Monkey link embedded in the introductory letter included in an email.

While interview questions were crafted and revised using feedback from the doctoral committee and the senior advisor, the results of this survey were also used to re-craft the interview questions. The questions included definitions of student-to-student discourse, frequency of use of student discourse, time on learning for science, the desire to increase time for discourse in science, value of using discourse to improve science learning, the extent to which professional development has been offered and useful, their desire for further training, areas of support: curriculum guides, district and school leadership, peers. The literature was referenced

to develop question focusing on instructional strategies: developing and reviewing norms, including all students, making sense of science ideas, and developing critical thinking skills.

The location to conduct the interviews was in the teachers' classrooms. This was intentional because to provide both the comfort of remaining in their "home context" and as a visitor the researcher would understand the conditions teachers' work within. The planning for collecting visual representations of classroom artifacts were planned to be requests as teachers referenced the artifacts in their interviews.

Data Collection Procedures

A phenomenological approach uses more than one data collection strategy to gain a more accurate picture of the phenomena in question. Collecting data using more than one method is known as triangulation and provides more breadth and depth to a study and to reduce the likelihood of misinterpretation (Creswell, 2007). Triangulation was critical to gaining an in-depth understanding of teacher perceptions regarding student-to-student discourse. This study recruited participants for two tasks: (1) to complete an online survey and (2) to be interviewed as a follow-up to survey completion, so the data collection occurred in two phases. The first phase collected data through an originally developed on-line survey using Survey Monkey and was followed by the second, interviews of a subset of teacher participants. The second was the collection of the data from the interview transcripts. Review and analysis of any artifacts collected during interviews was also included. Each of the two phases of the study collected data differently. The study did not use observations of teachers' lessons because the study is not evaluating teacher practice. All data was held in a locked file and a locked hard drive. Both were only accessible by the researcher and only shared with the dissertation committee.

Phase I: Pilot and Survey. An on-line survey created and piloted with five teachers in a different district. Their responses were used to revise the survey questions. The revised survey was presented to the researchers' committee and revised using their feedback to produce a final version of the survey. Subsequent to Human Subjects Review Committee approval of the study, and the school district's approval of the research, the survey was sent to district teachers of Kindergarten through grade five.

Potential survey respondents were recruited through an initial emailed letter introducing the study and included a link to an originally developed on-line survey. This was emailed in February of 2015 to 109 elementary teachers of grades Kindergarten through grade five in the school district chosen for the study (Appendix A). Additional encouragement to participate was sent to teachers by the district elementary science specialist. Fourteen respondents provided answers to the initial survey request. A second survey request was sent out three weeks after the first request to obtain additional responses. Nine additional participant responses were obtained in this second request. A total of twenty-three teachers responded to the survey. The on-line survey provider, Survey Monkey, automatically collected the survey responses and response data was guaranteed secure and only accessible by the researcher.

The survey instrument included 11 questions, eight that were closed questions using either a Likert rating scale or a choice of a range in percentages or time. The remaining three questions were open-ended for short answers. The Likert scale responses self-reported the degree to which they value student-to-student discourse, the frequency of use of student-to-student discourse for learning science, the extent of their professional development using student-to-student discourse, and their desire for further training. Additional questions addressed

the strategies teachers use to increase student participation in student-to-student discourse, as well as the identification of the conditions that support the instructional practice.

The survey data was collected through the on-line Survey Monkey site. When the survey closed, the results were downloaded as an Xcel spreadsheet by the researcher. The responses to the survey open response questions were separated from responses to the closed response items. Open response questions were copied and pasted on a word document then uploaded to Computer Assisted Qualitative Data Analysis Software (CAQDAS) for analysis.

Surveys are useful to capture a general opinion of a population (Creswell, 2014), and are easier to distribute through on-line platforms to a large population of potential respondents. However, surveys have limitations when researching more complex relationships like perceptions. Thus, the survey contained open response items that sought to shed light on participants' experiences with student-to-student discourse. In this study, the survey served to collect some useful data from respondents and to supplement the interviews.

Phase II: Interviews. The second task participants were recruited for was an interview. The interview was the primary method for data collection in this study. The emailed letter inviting participation in the survey apprised potential participants of the opportunity for voluntary interviews at the end of the survey. At the end of the survey, participants had the option to volunteer for interviewing and provide their contact information.

Eight teachers volunteered from respondents on the survey for an interview of 30 to 45 minutes in length. All interviews were in-person interviews conducted by the researcher. The preferred location was the teacher's classroom. The venue offered a comfortable and safe environment for the participant. Interviews conducted in the teacher's classroom optimized opportunity to photograph or copy artifacts for additional data. Researcher collected the

interview data by audio recording. The interviews were transcribed from the audio recording by the researcher, who transcribed three interviews, and a transcriber who completed five. The researcher checked all transcriptions a minimum of three times by listening to the audio recording while reading the transcript.

The interview protocol was designed with questions to gather more in-depth, anecdotal data to answer the three research questions. The research questions are variants of the two general questions asked of participants (Moustakas, 1994): (1) What have you experienced in terms of the phenomenon? (2) What contexts or situations have typically influenced or affected your experiences of the phenomenon? In this study the research questions that are variants of the first question were to learn teachers experiences with student-to-student discourse: do they value it, what are the instructional strategies they used. To the second question on contexts or situations, research questions focused on the factors and conditions that promote or inhibit the use of student-to-student discourse to increase student learning in science.

All interviews were conducted one-to-one in participants' classrooms. It was important to be in the actual environment in which the teachers worked for two reasons. First the teachers would be feel safe and relaxed in their classroom and would then be more inclined to greater candor in the interview. Second, as teachers referenced artifacts in their classrooms related to their use of student-to-student discourse a richer picture could be captured.

A process of member checking was integrated into the interview protocol to ensure reliability of the collected data. In this process, a narrative account of the individual interview was written up. When clarity was needed, the interviewed teachers were given the narrative account or consulted on the researcher's interpretation of their responses in the interview. In this

checking process, the teacher had the opportunity to discuss and clarify the interpretation as well as contribute new or additional information.

Researcher with the interviewees' permission collected artifacts: copies of norms charts, charts developed during discussions, and assessment tools or notes. These were kept electronically on the researcher's hard drive and uploaded into Atlas.ti, a Computer Assisted Qualitative Data Analysis Software (CAQDAS) for analysis on the researcher's computer.

Data Analysis and Synthesis

Making sense of the large amount of data collected presents a challenge to reduce the volume of information, identify significant patterns, and construct a framework. Data analysis and synthesis in phenomenology employs a process known as phenomenological reduction. This is a four-step process to reduce the data to the essence of the study participants' experiences. The four steps are bracketing (the role of the researcher), horizontalization, organizing invariant segments and themes, and constructing textural descriptions (Moustakas, 1994). The use of horizontalization assigns equal value to each statement that represents a segment of meaning respective to the research questions. These segments were clustered into themes. Segments and themes are synthesized into a textural (what they experienced) and structural (how they experienced) description for each participant. The descriptions were examined from different perspectives. In this method, and similar to other qualitative methods, the data analysis began as soon as the first set of data were available.

The formal process for data analysis began with a review of the survey using the tools available on Survey Monkey. The tables and charts offered a visual presentation of the data enabling quick analysis for patterns and themes. Survey data were transferred to an Excel spreadsheet because responses could be sorted and analyzed. the researcher used the three

guiding research questions as initial codes to assign the data from the survey and three interviews. The codes were written as headings on the top of large chart paper sheets. The statements were written on sticky notes and categorized manually on the chart paper sheets. The researcher then grouped these significant statements into categories or themes under each heading. This process was repeated twice, first with a member of the doctoral committee and then with another colleague to check for reliability of the code and themes. Initial coding served as an exercise to explore the data, provide a starting point for analysis, and to begin to understand the emerging similarities and differences between teachers' accounts. The researcher continued analysis with the remaining interview transcripts using preliminary codes and categories knowing that new codes may emerge and established codes may need revision. Researcher descriptions of participants' experiences were developed in short narratives made available to participants for their feedback on accuracy and clear representation of their experiences.

At this point, the volume of data required better management than the charts and sticky notes. Also needed was a means to present the those themes, patterns, and unique responses in a more quantifiable and visual manner. So, a Computer Assisted Qualitative Data Analysis Software, Atlas.ti, was purchased. An Atlas.ti "project was created and the interview transcriptions and survey open response were uploaded to the "project" for analysis.

When all data was entered in the CAQDAS, transcriptions were reviewed to become familiar with the contents and to ensure accurate transcription. Next, information was compared from teacher accounts describing different aspects of their experience to address the three research questions aligning participant statements with the research focus. Significant statements, phrases or sentences that provided an understanding of how the participant

experienced implementing of student-to-student discourse to learn science were coded. These were statements were that illustrate participants' experiences with student-to-student discourse (i.e. valuation, frequency of use, supports, barriers) the contexts and conditions that support or inhibit the instructional practice (i.e. support of colleagues, professional development, using norms, teacher modeling and teaching discourse behaviors & language). Moustakas (1994) refers to this process as horizontalization, where the same value is attributed to each piece of data. The subsequent coding resulted in thirty-three codes, each categorized in themes generated from the three guiding research questions. The resulting themes were reviewed for convergence and divergence. Comparisons of the similarities and differences informed the study of participant's experience with the supports and barriers for implementing student-to-student discourse for learning science. Additionally, this process highlights new questions to be asked and researched further.

In a qualitative study, a winnowing process of expanding, condensing, and eliminating categories throughout the research process in light of emerging understandings and interpretations is necessary. This study is no exception. Throughout the process, the data and themes were continually under review.

Issues of Trustworthiness

The data analysis process included attention to validity and reliability in three ways. First was the regular review of the data included on-going consultation with the senior advisor and the committee with regard to data coding and interpretation. Second was the use of a peer to compare coding with that of the peer. Finally, the integrating process of member checking where participants were consulted on the researcher's interpretation of their data offered validity

to the data and to its reliability. Participants had the opportunity to discuss and clarify the interpretation as well as contribute new or additional information.

A conscious effort was made to listen attentively to the teachers during their interviews both in person and recordings and to "bracket" (Creswell, 2007) my beliefs to allow for an impartial representation. As a method of bracketing my beliefs, interviewees were first apprised of the interview questions at the start of the interview. Interviewees were reminded of the value of their perspective to the study and assured of the confidentiality of their contributions. However, though I use a method to control for bias, my own experience and beliefs may influence the study.

Delimitations and Limitations of the Study

Delimitations. The researcher intentionally had chosen the delimitations that limited the study's scope and defined the boundaries. A broad topic like the perceptions of the supports and inhibitors for student-to-student discourse could be someone's life-work. Setting delimitations helped keep the study manageable in scale and in scope. Therefore, the sample in this study was limited to investigating elementary educators, and narrowed to a single district in the greater Metropolitan area in Massachusetts. This allowed for access during available hours for participants and within the constraints of the researchers' availability. The sample was further narrowed to the elementary educators have had some experience with student-to-student discourse. Experiences included both attendance at professional development and the use of the instructional strategy. This provided the study with data from teachers who had a working definition, experience with student-to-student discourse, and would be able to share their beliefs around the supports and inhibitors. The study did not include the perceptions and classroom practices of middle or high school teachers of science even though there may be transference.

Also, the researcher did not interview students, because the focus was on elementary teachers of science and their efforts to implement student-to-student discourse in the elementary classrooms and in science in particular. Nor did the study include school and curriculum administrators even though their perceptions and practices to support elementary teacher have been referenced by teacher participants. Finally, the study did not include families/ parents of elementary students and other key informants. Thus, a delimitation of the study was elementary teachers who have had experience with student-to-student discourse.

The second delimitation to the study was the time available to conduct and complete the collection and analysis of data. According to van Manen (2007) phenomenology requires immersion in the environment of the participants. Given more time, observations of teachers using student-to-student discourse, interacting with school leaders, and learning in professional development on student-to-student discourse would further enhance the data collected with rich descriptions. Potentially, the additional data would result in a fuller description of teachers' perceptions. While time limited the availability for immersion in the participants' environment, there was time spent in the building prior to and after interviews to observe the interactions between teachers and school leadership along with the collection and analysis of artifacts.

Limitations. This study contains limiting conditions related to both the limitations of qualitative research methods and those inherent in this study's research design. As the data and the analyses were collected and completed by the researcher, interpretation and results can be influenced by the researchers' perspective and bias. Several precautions were taken to mediate researcher bias, or to bracket, in developing instrumentation, data collection and analysis. These measures included use of note taking during the interviews, use of a peer to compare groupings of data, regular, on-going consultation with my senior advisor and committee, and member

checking with participants. The notes were reminders of my own thoughts and served as a means to refocus on the experiences the participant was communicating. Comparing coding of the data with that of the peer enabled me to ensure that the coding was independent of my own experiences. The regular review of the data included on-going consultation with the senior advisor and committee with regard to data coding and interpretation. Participants were consulted on the researcher's interpretation of their interview statements. This process, member checking, offered the participants an opportunity to clarify or contribute additional information. Member checking ensured that the experiences were those of the participants.

A second limitation was the potential for participants' guardedness during the interviews due to a reaction to researcher or to events in their school at that moment. Prior to the survey and to the interviews, participants had been apprised of the confidentiality of the data collected. Interviews were scheduled to accommodate the participants' schedules with one interview per day so that all were under optimal conditions. Additionally, having a peer listen to the interviews and track the shift in the participant guardedness from guarded to open in their descriptions helps to ensure objectivity. The shifts in the interviews were palpable as the responses became more enthusiastic and longer. The pattern was the interviews began with a few simple sentence responses and by the fourth questions, the participants' transcription answers stretched over a full page with details about a unit she developed and depended on student-to-student discourse. The trust and openness is evident in the descriptions presented in Chapter Four.

Summary

This chapter presented the research methods, procedures, and design of this qualitative study to answer the three guiding research questions. The rationale for a phenomenological

approach to the research was presented with the description of the research design. A phenomenological approach focused on how others are making sense of the world and was chosen to better understand the lived experiences and the perceptions of teachers who use student-to-student discourse as an instructional strategy.

The processes used to recruit participants, develop instrumentation, and collect data were explained. Participants were from a single district, met basic criteria (elementary teacher with experience using student-to-student discourse), and taught a range of grades (Kindergarten through grade 5). Instrumentation was developed using the literature reviewed as a resource for the survey. Survey responses informed the revising of interview questions. Formal data collection began with the survey and ended with the interviews at the participants' school. Researcher role elucidated control for potential bias, considerations of trustworthiness, as well as the delimitations and limitations of the study.

This chapter detailed analyses procedures consistent with phenomenological studies. This detailed process of analysis included re-immersion by listening to recordings and re-reading transcripts, condensing survey data, and reviewing notes and then "coding" using Computer Assisted Qualitative Data Analysis Software (Atlas.ti). These data enabled the researcher to make interpretations necessary to answer the study's three guiding questions. These findings are reported in Chapter Four.

CHAPTER FOUR: FINDINGS AND ANALYSIS

This study sought to provide insight into the perceptions of elementary teachers regarding their efforts to help students use student-to-student discourse in the science classroom. The overall goal of the study was to expand the understanding of the ways that teacher perceptions contribute to the gap between the existing research and current instructional practice. Classroom teachers decide on the practices for learning used in their classrooms. A growing body of research confirms the importance of student-to-student discourse for making meaning of science ideas and in moving students' conceptual development from intuited ideas towards a more scientific understanding (Barnes, 2008; R. A. Duschl et al., 2007). The findings of this research should be useful for teachers and curriculum specialists, school administrators including curriculum coordinators and directors, and universities that seek to support the development of teachers who teach science.

Phenomenological research methods guided the design and methods of this study. Chapter Three explained the method for addressing the three research questions through survey and interviews. The site for the research was purposefully selected because of the work the district had been doing with student-to-student discourse. The researcher had no connection with the site. All necessary permissions were obtained from the district and from individual teachers before the survey and each interview. An original survey developed by the researcher was sent in mid-February 2015 with a second invitation to participate sent in April to 108 elementary school teachers in grades K – 5 from a single school district. There were 22 respondents who began the survey, of those 17 completed the first five survey items, 15 respondents completed the following four items and 14 completed the survey. Although not all completed the survey,

there was a substantial amount of data gained from those that partially completed to include in the data analysis.

Table 1 shows the survey participants who identified the number of years they had been teaching elementary science ranges from two years to 39 years, with the majority self-identifying as teaching elementary science for more than 12 years. Only one respondent self-identified as having taught less than four years. Further, their years of teaching experience was in a broad range from two to 39 years, with 12 as the median and the mode, 15 the mean.

Table 1

Survey Respondents by Grade, Years of Experience and Time Teaching Science per Week

Grade	Years of experience
K	12
K	12
1	23
1	24
1	24
2	4
2	26
3	14
3	7
4	6
4	20
5	12
5	8
5	15 +
5	39
5	6
5	2

Follow-up interviews were conducted with teachers who volunteered after completing the survey. Out of the survey respondents, eight teachers volunteered and were interviewed in May and June of 2015. The teachers interviewed spanned Grade Kindergarten through Grade Five. Of the eight interviews conducted, two were teachers in Grade 5, two in Grade 4, one in Grade 3 who also taught Grade 2, one in Grade 1 who also taught Grade 2, one in Grade 2 who also taught Grade 1, and two in Grade Kindergarten. Data were collected and analyzed from the survey results and interview accounts of teacher perceptions of the value, supports, and barriers to using student-to-student discourse for learning science. Survey items and interview questions were developed in order to surface factors that contribute to the gap between the research on effective practice and actual classroom practice. The methodology is a non-linear, iterative process that proceeds simultaneously with other parts of the developing study (Creswell, 2007; Moustakas, 1994). For example, before interviewing teachers, an initial analysis was conducted of the survey data and this informed the development of the interview questions. Consistent with phenomenological research, the focus is on the participants' "lived experiences" and their perceptions about phenomena rather than to prove a theory.

As described in Chapter Three, survey data was downloaded from the on-line survey platform as an Excel spreadsheet. Closed response items were grouped and then copied and pasted into a table for analysis. Respondents to the three matrix questions provided ratings from a scale of "always, often, sometimes and never". For purposes of data analysis, responses for the categories of Always and Often were collapsed into a condensed category Always/Often. Similarly, the categories of Sometimes and Never were collapsed into a condensed category Sometimes/Never. Combining the four Likert scale categories into two nominal categories Always/Often and Sometimes/Never enabled the researcher to make a clearer comparison of the

responses. In some cases, the respondent thought a particular item was important, degree to which they took particular actions, and degree to which certain factors impacted their use of student-to-student discourse.

Interviews were transcribed as word documents, uploaded into Atlas.ti, the chosen Computer Assisted Qualitative Data Analysis Software, and subsequently coded using Atlas.ti qualitative data analysis software. Pseudonyms were used for all interview participants. All transcripts and open response survey responses were uploaded into a file created for this research. The software is a tool to manage the data and the process of analysis, which is coding significant statements, categorizing codes as themes, annotating transcripts, retrieving, and searching within and across documents and categories and themes. Reports were generated using the software through queries that show the code frequencies in individual categories within a theme and, generate a report for a particular category and or a theme or code with quotations from the transcripts and the open response survey items. Atlas.ti was used as a management tool that enabled the researcher to manage and analyze all the qualitative data in this study.

Artifacts gathered were in the form of photographs of classroom norm posters and teacher developed note cards or sheets on clipboards for collecting anecdotal data during students-to-student discourse. These artifacts did not yield further information regarding teacher use of student-to-student discourse beyond that expressed by teachers in the interviews.

In this chapter, the term *community* refers to the school or classroom community made up of the teacher, other adults who assist or teach special areas, and students. The term *specialist* refers to teachers for the special subject areas: Art, Music, Physical Education, and Library where students leave the classroom for these subjects. The phrase *special services* refers to services provided to students as determined by specialized testing through a designated program

where students receive additional support or instruction either in the classroom or out of the classroom by Learning Center teacher or English as a Second Language teacher.

This chapter presents the research data and findings in three main sections. Each section organizes and presents the research data and findings to address each of the three research questions. The three research questions that guided the study:

1. To what degree do elementary teachers who teach science consider student-to-student discourse to be an important means to improve learning in science?
2. What are the various ways elementary teachers of science report they are using student-to-student discourse to increase student learning in science?
3. What are the supports and barriers elementary teachers of science identify as promoting and inhibiting their use of student-to-student discourse to increase student learning in science?

The guiding research questions form a framework for organizing the reporting of the data and findings. The data for each question are presented within the context of that question. The data from the survey are presented first, while the data from the interviews are described second. The chapter concludes with a summary of the study's major findings.

Research Question One: To What Extent Do Elementary Teachers Value Student-to-Student Discourse?

Elementary teachers in this research study were asked to describe their experiences with using student-to-student discourse to improve student learning in science. As they responded to the survey and in interviews, teachers shared their successes and the challenges using this teaching strategy. While they readily shared the successes associated with their use of student-to-student discourse and their pleasure in students' increased science learning, there were

striking similarities in the challenges they routinely faced using this strategy. Their accounts provide insights into elementary science teaching using student-to-student discourse, how teachers value this strategy, the ways they use the strategy, and the supports they desire. Further, recognizing the supports and the inhibitors to using the strategy helps us better understand the conditions that need to be in place for effective use of the strategy in elementary schools to further science learning.

The intent of the first research question guiding this study was to determine the degree to which elementary teachers who teach science consider student-to-student discourse an important means to improve learning. Before one could determine if teachers even value student-to-student discourse, it was essential to know if teachers have a working definition of student-to-student discourse and how their understanding aligned with the descriptions in the literature. Items on the survey and questions in the interview asked teachers to use their own words to define student-to-student discourse.

Defining Student-to-Student Discourse

One open response item on the survey and in the interview asked teachers to provide a definition of student-to-student discourse in science. The responses were reviewed and led to the establishment of representative coding categories for teachers' comments. The summary of these results follows.

All 17 respondents to this survey item mentioned that students are engaged in a discussion with other students. Phrases used included “group discussions”, “everyone participates”, “with the whole class”, and “science circle”. One respondent’s description exemplified respondents’ definition of student-to-student discourse in science. “Students talking informally as they observe specimens, experiments; students planning experiments; students sharing observations, claims, hypotheses with other students/class”. In the survey, teachers

defined student-to-student discourse in science as centered on students sharing their science ideas during investigations, and with the class. Of the 17 definitions, six specifically mentioned whole group or class discussions using two similar phrases. These similar phrases were "Students working together during science instruction" and "Students working together and talking about their ideas". All participants' definitions described students talking with other students about their science ideas and processes.

Similarly, the responses to the first interview question, "What does the term student-to-student discourse mean to you?", all described students talking with peers. In the interviews, all participants described student-to-student discourse as students talking with other students to make sense of science concepts by comparing their ideas to others.

> "Kids talk with a partner or a small group about their ideas about a particular concept and then listen to other people's ideas and then think about how that matches what they think or how that doesn't match what they think." (Barbara V., grade 1 and 2)

Through this process they can add on another student's idea, furthering their science knowledge.

> "I kind of step back and they do the discussing, no hands raised, just back and forth and it's really interesting because they piggy back a lot on each other's ideas." (Katie T. grade 1 and 2)

Teachers define student-to-student discourse in science as talk or discussions between students where students make sense of new science information from their investigations and of their peers' ideas.

Teacher definitions of student-to-student discourse were consistent with the literature where student-to-student talk is between students (Barnes, 2008; Scott, 1998) and where students make their science ideas public in discussion with their peers, and arrive at a more scientific

understanding (Sarah Michaels et al., 2008). However, developing critical thinking skills was omitted from their definitions.

Time use as an Indicator of Value

To help ascertain the value teachers place on student-to student discourse in science as an important means to improving learning in science, survey items focused on the time teachers spent in class for student-to-student discourse and the time they would spend under ideal conditions. Interview questions asked participants for descriptions and anecdotes to describe the benefits they have seen from using student-to-student discourse for learning science. The degree to which teachers understood and could articulate the benefits of student-to-student discourse and the time teachers set aside for using the strategy are indicators of the degree to which they value student-to-student discourse as a means to improving teaching in science.

Survey data was collected and compared as an indicator of the degree to which teachers value student-to-student discourse as an important means to improve learning in science. In order to contrast data, responses from survey items three through five regarding the grade level taught, years of experience teaching elementary science, and the amount of time in a range spent teaching science per week is represented in Table 2 along with the responses from survey item seven. Survey item seven was constructed in two parts. Respondents first identified from a range the percentage of time they currently spend using student-to-student discourse for learning science, and, second, they identified from the same range the percentage of time they would use student-to-student discourse under ideal conditions. These responses were analyzed and used to identify points in the data that act as indicators of the value the respondents placed on time used for student-to-student discourse in science learning in the elementary classroom. If the respondents preferred to increase the time for student-to-student discourse, the indication was

that teachers value student-to-student discourse for increasing learning in science. If the respondents preferred to reduce the time, then the data indicated that teachers did not value student-to-student discourse for learning science. Further analysis of the survey data collected on the grade level taught and the number of years teaching offered an opportunity to find any relationships between these data and the value teachers place on student-to-student discourse for learning science.

Responses to item seven were contrasted in a table comparing the time respondents report they are currently using student-to-student talk with the time respondents would spend under ideal circumstances (see Table 2). In order to determine if the increase was of any significance, the percentages teachers identified required translation into minutes. The data from item five, where teachers indicated the number of minutes they taught science each week, was used for calculation from percentages to the number of minutes that teachers identified they currently used student-to-student discourse and the number of minutes they would under ideal circumstances. The conversion of the data from percentage into minutes is included in Table 2.

Table 2

Survey: Comparison of Time per Week Currently Used and Desired Use Under Ideal Circumstances in Percentages

	Current use		Under ideal circumstance	
Grade	Percentage	Minutes	Percentage	Minutes
K	30%	12 - 18	50%	20 - 30
K	60%	24 - 36	80%	32 - 48
1	20%	13 - 18	50%	33 - 45
1	50%	33 - 45	50%	33 - 45
1	60%	39 - 54	90%	59 - 81
2	20%	8 - 12	50%	20 - 30
2	60%	39 - 54	80%	52 - 72
3	50%	20 - 30	70%	28 - 42
3	70%	66 - 84	80%	76 -96
4	30%	19 - 27	60%	38 - 54
4	50%	60 - 90	80%	96 - 144
5	60%	24 -36	80%	32 - 48
5	60%	39 - 54	70%	46 - 63
5				
5	50%	60 - 90	50%	60 - 90
5				
5	80%	148 - 192	100%	185 – 240

The current use of student-to-student discourse ranged from 20% to 80%. In contrast, responses regarding the percentage of time respondents would use student-to-student discourse under ideal circumstances ranged from 50% to 100%. Of the fifteen respondents to this item, all but two would increase the percentage of time they use student-to-student discourse for learning science;

the thirteen other teachers responded that they would increase the time by at least 10% and, in six cases, as much as 30%.

Interview participants were asked how frequently they used student-to-student discourse**.** The frequency that participants described varied. Discussions were described as being used as a starting place for a science investigation to uncover students' ideas, during lessons where students make sense of their work with each other, and at the end of the lesson as a means to consolidate student learning. Fourth grade teacher Melina's description illustrates the experiences of other participants.

> "I like to provide it a couple times during the week and I do it at the end of the science lesson sometimes just really to wrap up and see what they had (understood) before they write results the next day" (Melina S.).

Teachers perceive that student-to-student discourse has value for improving student learning.

There were two indictors of teachers' value associated with student-to-student discourse. First, teachers indicated that they would increase the use of student-to-student discourse under ideal circumstances. This trend to increase use of limited time in the school day for science learning is an indicator that teachers value student-to-student discourse as a means to improve students' learning in science. Second, teachers employ this instructional strategy in their lessons with some regularity, rather than on a rare occasion; all interviewees indicated that using student-to-student discourse was part of their regular classroom routine.

Benefits of Student-to-Student Discourse

In order to delve more deeply into the teachers' perceptions of the value of student-to-student discourse, interview participants were asked to indicate the degree to which they value the use of student-to-student discourse for learning science. Participants were asked to explain

the reasons they consider student-to-student discourse to be an important pedagogical approach for learning science. Follow-up questions asked participants to explain further by describing, from their experience, the benefits of student-to-student discourse for learning science.

Teachers' perceptions of the benefits of student-to-student discourse were organized into three general themes. These three themes are consistent with the themes of research discussed in Chapter Two. The themes were: participation of all students (Cazden, 2001; Sarah Michaels et al., 2008), meaning or sense making (Dawes, Dore, Loxley, & Nicholls, 2010; R. A. Duschl & Osborne, 2002; Scott, 1998), and developing critical thinking skills for current and future use (Sarah Michaels et al., 2008; National Research Council (U.S.), 2012).

Commonalities existed in participants' responses to the benefits of student-to-student discourse as means to improve students' learning as shown in Table 3. All interview participants mentioned the value of student-to-student discourse for learning science as sense making and developing critical thinking skills. Seven of the eight participants, or 88%, mentioned the value of student-to-student discourse as including all students.

Table 3

Survey: Number of Interview Participants, Responses, and Percentages for Benefits of Student-to-Student Discourse for Learning

Benefits Category	Participants	Responses	Percentage
Including all students	8	7	88%
Sense making	8	8	100%
Develop critical thinking skills	8	8	100%

The benefit of including all students in the learning. Providing all students with the opportunity to become scientifically literate is an issue of equity (Cazden, 2001; Sarah Michaels

et al., 2008). If all students are to understand the ideas and content of science and they grow up to be contributing members of today's world, then it is incumbent on teachers to provide the opportunity for all students to learn the practices and core ideas of science. Survey respondents rated the capacity of all students to engage in discourse as important. Table 4 shows that 100% of the respondents believe that students are always or often able to engage in discourse.

Table 4

Survey: Teacher Perceptions of Student Capacity to Engage in Discourse

Factor	Always/ Often	Sometimes/ Never
Q 11: What is the degree to which the following are important?		
Think all students have the capacity to engage in discourse	100%	0%

Interview participants reported that student-to-student discourse encourages a wider range of students to participate in the learning. This wider range included quieter students who tend not to participate in whole-class discussion, English as a Second Language learners, and students on Individual Education Plans. For these students, partnerships or the small-group configuration seems to be beneficial. As Kindergarten teacher Louise described,

> "I think that especially kids that either are more quiet or kids that are ELL students, having them talking with someone else that might be a little stronger in that area, brings out more of the child that is quieter." (Louise F.)

Another strategy described was to pair two struggling students together to make sense of new information or to figure something out.

> "If I put two students together that tend to struggle individually, I've seen them sort of do that brain storm process and get a little bit farther along in their thinking then they would have on their own." (Catalina S., grade 4).

Fourth grade teacher Melina described quieter students who do not speak in large groups as benefiting in the small group configuration because they feel more comfortable to talk and share their ideas.

> "Because they're working in teams of four and for children that have a really hard time speaking up in front of a group but have great ideas, they might be more apt to do it in a smaller group." (Melina S.)

In describing a child on an Individual Education Plan, Kindergarten teacher Lynda described use of the small group configuration as an opportunity for her to see what the student knew and how the student was able to participate in the small group whereas he was lost in the large group.

> "I saw his strengths in the small group but I lost it in the large group, so it's really important, even though it was almost the same project, it was just scaled bigger so I lost him in that scale bigger even though we tried to slow him down and have him help, he couldn't do it, but in that small group, he could." (Lynda K.)

First and second grade teacher Barbara V. describes the benefit of student-to-student discourse for English Language Learners:

> "Some kids who come from other countries, they don't have academic language yet to have these kinds of deep conversations yet, it just takes time. They have to do a lot of observing and they have to do a lot of taking all the language in first. (Barbara V.)

Similar to other interviewees, Barbara believes that ELL students' participation offers an opportunity to develop receptive language as they learn English as a second language.

First and second grade teacher Katie T. describes the benefit for all students learning the tools of student to student discourse:

> "This being open to hearing others and being able to exchange and not just interact is just the best tool we can be giving them right now. It's just the best tool. If we're leaving them with anything in their tool box, that opportunity and that experience is the most valuable, I think. The other stuff, they're picking it up but that ability to do that kind of work and that kind of exchange is going to be the biggest thing they have in their tool box." (Katie T.)

These teachers recognize that providing for the wide range of learning styles and needs in classrooms is supported by the use of student-to-student discourse.

The benefit of making sense of science ideas. Sense making refers to the process in student-to-student discourse where students make sense of a newly present scientific idea challenging their pre-existing ideas or concept. Eleven survey respondents' definitions included descriptions that indicated the value of sense making or making meaning of new information. Respondents described student-to-student discourse as "authentic discussions of concepts and findings" with the purpose of increasing student learning in science.

Sense making was most frequently mentioned in the interviews as a value for using student-to-student discourse to improve learning. Among the eight participants, this phrase was mentioned 16 times through the interviews. As Louise F., a Kindergarten teacher commented,

> "They're kind of figuring it out themselves and talking with a friend and when they talk together they learn a lot more, I think, than when it's just me telling them something. They make a lot of meaning through those conversations together." (Louise F.).

All participants described the use of student-to-student discourse as an important means to improve science learning because discourse required students to make sense of new information.

Some participants described student-to-student discourse as more effective than the teacher telling students the correct information. Second grade teacher Barbara V. explained,

> "I'm not the sole distributor of all information and they don't always have to come to me. They can use each other as a resource and they can use the world as their resource to learn and grow." (Barbara V., grade 1 and 2).

Teachers believe that student discussions help create a learning community that is not solely reliant on the teacher.

Lynda K. described her idea that students need to make an effort to learn.

> "When they're just thinking themselves, they're not pushing themselves, so when they're talking to each other, they're discovering more and bringing their learning to a higher level" (Lynda K.)

According to Kindergarten teacher Lynda K., the interaction between students in discourse requires students to consider others' ideas and to express their own ideas clearly.

Teachers in this study reported value in the discourse between students as they share information and ideas and push each other to think differently. One participant contrasted learning together through student-to student discourse with individual learning;

> "They get to help each other figure things out or they get to work things out together as opposed to just having that one, you're all by yourself." (Catalina S., grade 4)

Teachers also mentioned that students help each other make sense of new information and push each other's thinking so the students learn more than if the teacher reads a book to them or told them information.

> "So, they're still grappling a little bit with that but they'll talk to each other about it which is so much better than me up there saying read this in a book or let me show you this, it's just so much more rewarding to them because they have made this discovery and they have figured out how to apply it themselves." (Katie T., grade 1 and 2)

The process of meaning-making is important in learning information as students own their new-found understanding.

Students need to make sense of what they are learning in terms of their prior ideas. Discourse offers students the opportunity to articulate their own ideas and to grapple with new or different ideas and make sense of them in light of their prior knowledge and beliefs. As Kristen S. described,

> "So, they're still grappling a little bit with that [new idea] but they'll talk to each other about it which is so much better than me up there saying read this in a book or let me show you this, it's just so much more rewarding to them because <u>they</u> have made this discovery and <u>they</u> have figured out how to apply themselves." (Katie T. grade 1 and 2)

Teachers noted that the discussions are not linear, but rather take a circuitous route as students consider other ideas that may seem off topic. However, teachers explained that after students consider other ideas, the path science discourse takes settles on a more scientific explanation.

> "To me the most beneficial part is that they lead each other down the right track eventually because they seem to know how to go about talking to each other in a way that searches out an answer that makes logical sense to them and they can hold and reapply. They tend to go the right direction. For them to make the discoveries and be able to apply it themselves. And helping each other get there." (Katie T., grade 1 and 2)

As a Kindergarten teacher, Louise F. emphasized the behaviors that scientists use to observe objects and phenomena as what scientists do. In describing the value of student-to-student discourse for student learning, Louise F. contrasted student-to-student discourse with teacher-led direct instruction or lecture.

> "So, having that discussion [about how scientists work] has them thinking, oh that's what scientists do, and it kind of gives them like a light bulb moment sometimes. So, those discussions are really important, it's not always me just telling them what they need to know. They're kind of figuring it out themselves and talking with a friend and when they talk together they learn a lot more, I think, than when it's just me telling them something. They make a lot of meaning through those conversations together." (Louise F.)

First and Second grade teacher Barbara V. captured the thoughts of teachers in her description of the benefits of student-to-student discourse in science when students have to explain their science ideas to each other. The process of articulating and explaining their ideas to another person appears to solidify the concept for the student.

> "Until they really have to think about it [their science idea] and articulate it and verbalize it, and explain it to somebody, I don't think it really sticks in their head. So, I think that that talking is the really important piece for learning." (Barbara V.)

These teachers recognize the benefit of discourse in helping students make sense of what they are seeing in the science classroom.

The benefit of developing critical thinking skills. Discourse in classrooms offers the opportunity for students to become critical thinkers. Critical thinking skills include using evidence to support claims, building on others' ideas or offering a counterexample, and

responding to others' ideas by engaging in argumentation by agreeing or disagreeing with a peer's idea based on evidence (Sarah Michaels & O'Connor, 2012). Current research claims that students can be taught to develop skills to think critically (McNeill & Krajcik, 2009a; Sarah Michaels et al., 2008). As critical thinkers, students develop the ability to evaluate scientific information by considering the reliability of the data and the methodology employed, so that they develop the capacity to construct and evaluate arguments based on evidence.

Two survey respondents included descriptions of critical thinking skills in their definitions of student-to-student discourse. One descriptive phrase that exemplifies discourse as helping students to learn critical thinking skills was "students building on each other's ideas, confirming or disagreeing with claims". While another respondent was more specific about developing critical thinking skills where students engage in academic argument; "confirm or disagree with claims".

Similar to the survey descriptions, three interview participants described developing critical thinking skills through student-to-student discourse. Fifth grade teacher Elizabeth's description of teaching these skills during student-to-student discourse in her classroom presents a picture of the language teachers model for students.

> "I will always challenge [students], we use the turn and talk moves a lot, so I'm always saying "do you disagree, do you agree, would anyone like to challenge that statement, can you add on, can anyone add on to so and so's thinking". It's always taking it to the next level." (Elizabeth H.)

Elizabeth continues describing the value for students to hear different ideas and the effect on students in thinking about their ideas and changing them.

> "Student talk usually leads them to combining all their background knowledge and I think it's really important that they hear from other students and hear different ideas, it helps them reshape their thinking". (Elizabeth H.)

Melina S. described bringing in new ideas for consideration by students in the discussion.

> "I think for the kids it's talking to each other, that back and forth because they make each other think of things they hadn't thought of before and also, very politely, will say, 'I politely disagree with you because…' and they say, oh gosh, I forgot about that, or they bring in their own prior knowledge and it helps to figure out if this is really a new fact or if it's a misconception or if we confirm that it's true." (Melina S.)

Elizabeth concurs and describes discourse between students as furthering their knowledge using real life examples:

> "It's the discussion that enriches the science material in general. That they are able to turn to anyone at any point and be able to have a discussion either in a partnership or in a group and build off the content, they're given an answer to a question or respond to an answer, sort of to further their knowledge without always having, I feel like sometimes discussions are more rich than other activities because then they're finding out how other students are thinking and it gives them a real-life example to agree or disagree." (Elizabeth H.)

Katie T. describes the discourse between students as comparing and contrasting their ideas. Through this process students come to an agreed upon science explanation. She explained that through discussion students compared ideas and came to a scientifically accurate conclusion that made sense to them.

> "For me it means that the students are doing what they know and what they've

> experienced and discussing with each other how it is and talking about it and manipulating each other's minds not me doing the manipulation but them manipulating it and then adding their pieces in search of what they think is the fact." (Katie T.)

These three teachers described the benefit of discourse in helping students develop critical thinking skills regarding their own ideas and peers' ideas in the science classroom.

Discussion of the Findings for Research Question One

Finding 1: Teachers value student-to-student discourse as an effective means for increasing students' science learning. Teachers indicated the value by describing the benefits of student-to-student discourse for learning science: including all students, sense making of new science ideas, developing critical thinking skills. Teachers' in this study used a variety of phrases to define student-to-student discourse as talk between students about their science ideas explaining a science phenomenon. Teachers believe that all students are included and have opportunity and support to engage in student-to-student discourse. The use of student-to-student discourse supports providing for the wide range of learning styles and needs in classrooms. Through discussion with peers, students listen, compare, and make sense of different ideas to think more scientifically. Teachers in this study recognize the benefit of discourse in helping students develop critical thinking skills regarding their own ideas and peers' ideas in the science classroom. The data suggest that teachers value student-to-student discourse as an important means to improve learning in science because the strategy increases students' ability to make sense of their ideas, develops important critical thinking skills, and encourages all students to be actively engaged in science.

While many descriptions were consistent with the literature where student-to-student talk is between students (Barnes, 2008; Scott, 1998) where students make their science ideas public

in discussion with their peers, consider other ideas, and arrive at a more scientific understanding (Sarah Michaels, O'Connor, & Resnick, 2008); teachers do not have a clear statement of definition for student-to-student discourse in science.

Finding 2: Teachers would choose to devote more time for student-to-student discourse in science if ideal conditions were provided. The survey data show that teachers devote an average of 50% of their time to using student-to-student discourse as a student learning strategy but would devote 70% of their time under ideal conditions. The interview data suggests elementary teachers work within the amount of time and opportunity they have to teach science using student-to-student discourse. However, the survey data also clearly show that teachers across the spectrum would increase the use of student-to-student discourse under ideal circumstances. This desire to increase the time to use student-to-student discourse is another indicator that teachers value student-to-student discourse as a means to improve student learning.

Summary

Research Question one found that this study's participants value student-to-student discourse as a valuable means to increase student science learning. A critical finding because it sets the foundation from which other findings would emerge. These teachers believe the benefits of student-to-student discourse are including all students, making sense of science ideas, and developing critical thinking skills. Additionally, teachers in this study indicated they would increase the time for teaching science in order to include more time for student-to-student discourse from a median of 50% of their science instruction time to an average of 70%.

The degree to which teachers value student-to-student discourse cannot be fully understood without inquiring into the behaviors of teachers with regard to student-to-student discourse. If teachers believe that using student-to-student discourse for learning science is

valuable, then the degree they value it is revealed in their actions. Their actions are revealed in their descriptions of the various strategies they use to foster student-to-student discourse to increase student science learning. The converse is also true, strategies teachers do not value for fostering student-to-student discourse to learn science will not be described. Question Two examines the themes that emerged when teachers were asked about the various teaching strategies they use to promote and encourage student-to-student discourse in the science classroom.

Research Question Two: What are the Teaching Strategies used to Foster Student-to-Student Discourse in Science?

The second research question guiding this study went beyond teachers' perceptions of the value of student-to-student discourse. Items on the survey and questions in the interviews were designed to help learn the strategies teachers use for student-to student discourse to increase learning in science. The teacher has a fundamental role in developing the capacity of students to successfully engage in student-to-student discourse for learning science. Three broad sets of teacher responsibilities help students become effective users of discourse to improve their learning; (1) configuring the discussions to promote student-to-student discourse; (2) setting norms for class behavior; and (3) teaching specific skills of discourse that align with practices of science. All three are woven together in the establishment of a classroom culture that values and includes student-to-student discourse for learning. A fourth, unexpected strategy, was teacher use of student-to-student discourse as formative assessment of student learning. In student-to-student discourse teachers listen and identify concepts that students are struggling to understand or skills they are having difficulty acquiring so that adjustments can be made to lessons or instruction.

Teaching Strategy 1: Student Configurations to Promote Student-to-Student Discourse

Survey respondents described the various student configurations or groupings used to manage student-to-student discourse in their definitions of student-to-student discourse. Table 5 reflects survey respondents' descriptions of the configurations used for student-to-student discourse. The table includes the number of responses describing that configuration, and the grade level of the respondent. The three typical configurations are partnerships, small groups, or whole class discussions. Teachers across grade spans use a variety of configurations for student-to-student discourse.

Table 5

Survey: Configurations Described for Student-to-Student Discourse

Configurations	Grade	Number of Responses
Partnership	K, 1, 2, 3,5	5
Small Group	5, 5	2
Whole Class	K, K, 1, 2, 3, 4, 5, 5	8

Similarly, interview participants described the same three configurations for student-to-student discourse: partnerships, small groups, and whole class.

Partnership configuration. Survey respondents defining student-to-student discourse frequently described partnerships as turn and talk. Turn and talk is an instructional routine where the students are instructed to turn to their partner and talk to answer a specific question posed by the teacher. This strategy is often employed within a whole group lesson by the teacher in order to make student thinking visible (Hattie, 2008). Five survey respondents described this routine for using a partnership configuration in their definitions of student-to-student discourse.

All interview participants mentioned turn and talk, a routine for student-to-student discourse between partners. Teacher's use of this routine was either random pairings or strategic pairings. Typically, random pairings were described as assignment of partners based on where students may be sitting in the classroom. Fifth grade teacher Elizabeth uses the routine frequently so that students know what the expectation is for partner discussions.

> "Students are able to turn to anyone at any point and be able to have a discussion either in a partnership or in a group and build off the content" (Elizabeth K.).

Kindergarten teacher Lynda K. offered a detailed description of strategic pairing to challenge all students and for socialization.

> "I try to pair them up so that the pairings are going to bring out the best in both sides. And that works for the high learners, too, because often times, the high learners think they know it all so I want to make sure that 1) they're challenged, but also 2) they're taking care of the other children in the classroom … they're learning how to work with others and hear both sides." (Lynda K.)

Lynda strategically pairs students as means to increase student science learning.

When interview participants described using more than one configuration in a lesson, they also explained how they sequenced the configurations. For example, when they described using partnerships, they then explained the partnership discussion occurred first and then led to a whole class discussion.

Pairing students in partnerships, and in particular use of turn and talk, was the most commonly described configuration for student-to-student talk.

Small group configuration. In a small group configuration, students work in groups of three or four, sharing materials and ideas as they work, and coming up with shared solutions. The

teacher is generally circulating among other groups, but will step in as needed to assist or answer questions. The survey data show only two fifth grade classrooms use a small group configuration.

In the interviews, all teachers described the use of small group discussions when students were investigating science phenomena. During the investigation, students would think aloud which led to discussion with other students in their group. Lynda K.'s description reveals a process of evolving ideas she has observed with students.

> "For that kind of thinking process, they're constantly talking out loud and someone else is grabbing their thought, so I think that really helped. It's not always talking to each other, sometimes it's just that the ideas are flowing and someone's grabbing ideas [building on another's idea] and running with them and [saying] let's try this and what about this and it's wonderful to watch." (Lynda K.)

Small groups were described as useful configuration for students to engage in discourse with peers to make sense of and further one another's ideas in science.

Whole class configuration. Whole class is a common configuration for discussion in classrooms. In this study, teachers described their use of whole class discussion to begin a lesson or investigation and to wrap-up a lesson or investigation. Two examples of ways teachers use student-to-student discourse to begin a lesson are to elicit student ideas. Kindergarten teacher Louise described a discussion eliciting student ideas of things they might see on a walk in the schoolyard at the start of the lesson.

> "We start talking in the large group about all the things we might see or might notice." (Louise F.)

Fifth grade teacher Kristen described a discussion eliciting student predictions. First, students think about their ideas, and then she elicits their ideas in a whole class discussion.

Teachers in all grades described using student-to-student discourse as a wrap-up routine where students "come back to a whole group to share what we learned." (Lynda K). Two descriptions that illustrate this practice follow.

> "They all take their chairs and they sit on the outside of the room and I sit with them in the circle but they know that I'm usually not talking." (Elizabeth H.).
>
> "We're talking as a group and I'm not part of that, they are, I just pose the question and then I kind of step back and they do the discussing, no hands raised, just back and forth and it's really interesting because they piggy back a lot on each other's ideas." (Melina S.)

All teachers in this study used whole group, student-to-student discourse to begin or to wrap up science lessons.

To summarize, three configurations are used for student-to-student discourse: partnerships, small group, and whole class.

Teaching Strategy 2: Setting Norms for Class Behavior

Research had shown the creation of norms for discourse and the review of the norms before discourse as critical to student-to-student discourse. In order for students to share their ideas, it is critical to establish norms of respect and equity, so students know their ideas will be taken seriously and they can work through their own reasoning without fear of disrespect (S. Michaels & O'Connor, 2015). Teachers in this study work to build a classroom climate of trust or psychological safety so that students can productively engage in discourse with each other. Survey respondents indicated the importance of two items regarding setting norms for student-to-

student discourse: set norms for discussions and review science discussion norms. Artifacts collected were charts of classroom norms for behavior and did not expand on information from the interviews.

Table 6 shows 79% of respondents indicated setting norms for use in the student-to-student discussions is important, only 43% indicated review of the norms as important. While most teachers set norms, most teachers did not review these norms as a reminder to students of their agreed upon behaviors before discussion begin.

Table 6

Survey: Norm Setting and Review Ranked by Importance

Items	Always/ Often	Sometimes/ Never
Q 11: What is the degree to which the following are important?		
Set norms for discussions	79%	21%
Review science discussion norms	43%	57%

Interview participants all mentioned ways they build a classroom climate of trust so that productive discourse can take place between students. Teachers report they spend more time at the beginning of the school year creating expectations for the classroom community. Kristen's description illustrated the reasoning why teachers establish classrooms norms and expectations at the beginning of the year.

> "By the time we get into the real academics, we're on the way to building those trustful relationships." (Kristen S.).

Lynda K., as did all teachers, had a class made poster of "class rules" prominently hanging in her kindergarten classroom. These rules focused on classroom behaviors.

Melina, a fourth-grade teacher, described that in the context of agreed upon class rules or norms, students can feel safe, can take risks, and learn from failure. As a classroom community, Melina and her students work on creating trust all year long through using classroom discussions to increase learning and to solve social issues.

> "You have to create that climate where you become like a family and once that's in place then they are willing to take risks, not just in the social piece but academically too, it's something that you do all year. I mean it's coming up with classroom rules together, it's sitting on a weekly basis of talking, like what are some problems that you saw in the classroom, share ideas. (Melina S.)

Barbara added another dimension that students need to feel safe so that they give up ideas for new ones.

> "If you could build that sense of community in the classroom and build the atmosphere where it's OK to talk, it's OK to be wrong, it's OK to say what you think, but you also have to be willing to let go of some ideas [misconceptions] and change [initial ideas], then those conversations can happen a little bit more freely. (Barbara V.)

Teachers build trust by creating charts for classroom behavior in collaboration with students. However, only two fifth grade teachers and one fourth teacher described having a chart of norms or rules specifically for student-to-student discourse developed with the students. Of these three, two specifically described reading the norms before each discussion as a reminder.

Although they rarely or never read them before each discussion, all teachers described revisiting the norms when students broke the norms. Some teachers have students read their chart when the norms are not followed and ask students to review discussion behavior in terms of the

class norms at a discussions end. However, most teachers reported referencing class norms only when students do not follow them. Elizabeth's description captures this use of norms.

"As the problems arise, then we read the norms together." (Elizabeth H.).

All participants described developing and using classroom behavior norms as a means to build trust and mutual respect between students and the teacher in the classroom community. While all teachers described using classroom norms for science discussions, only three teachers developed discussion norms. Further, two teachers described a routine to read the norms at the start of classroom discussions, and the majority reported they only read them when student misbehavior warranted a reminder.

Teaching Strategy 3: Teaching Specific Skills of Discourse

Teachers in this study described the use of discourse for increasing student science learning in terms of students learning the skills of discourse. These skills are important because students use them to engage in the practices of science: generating explanations, using evidence to support a claim, considering and evaluating alternate explanations, and engaging in argument (McNeill et al., 2006). Since all students do not come to school with these skills, students need to develop the skills and dispositions of student-to-student discourse so they can engage in discourse that will increase their science learning.

Survey item 11 contained six items that required respondents to rank the discourse skills used to promote student-to-student discourse to increase science learning.

Table 7 depicts respondents' ratings of these items as percentages.

Table 7

Survey: Skills of Discourse Ranked as Important

Items	Always/ Often	Sometimes/ Never
Q 11: What is the degree to which the following are important?		
Encourage students to challenge each other's ideas	43%	57%
Ask students to explain in their own words what someone else means	71%	29%
Ask students for evidence to back their claim or idea	93%	7%
Ask students for a different idea	100%	0%
Ask students to expand on another student's ideas	71%	29%
Ask students to show listening skills by repeating what a peer said	57%	43%

Interviewees were asked to describe the discourse skills they purposefully teach students. The data are categorized and discussed here relative to four important roles teachers take on to help students learn and use discourse skills: (1) help individual students explain their thoughts; (2) help students listen to others' ideas; (3) help students deepen their reasoning; (4) help students engage with others' reasoning.

Teacher role: Help individual students explain their ideas. Survey respondents included in their definitions of student-to-student discourse descriptions of the routines to encourage students to explain their ideas. One respondent described students sharing their ideas, "Students working together and talking about their ideas." Another wrote, "Empowering students to have discussions of concepts and findings." Teachers described students sharing their ideas with peers and in the process learning from each other and expanding and clarifying their thinking. One respondent wrote, "Talking through steps and questioning." Another wrote, "students to share, observe, engage, and process together [talk about their ideas] as they learn."

In defining student-to-student discourse, respondents described students sharing, explaining and clarifying their thinking through student-to-student discourse.

Similar to how respondents answered the survey questions respondents, interview participants described how they encourage students to share, explain, and clarify their thinking using student-to-student discourse. Louise describes the progression from the start of the year in kindergarten.

> "Definitely in the beginning when we first started, … they'll be talking about something that has nothing to do with the lesson that we did or about science or even about something in our classroom, so I think that training them from the beginning takes a lot of patience and time and I sometimes have to be like, OK as long as they've turned and they're sitting crisscross and they're looking at their partner – those are the three things I want them to do first and slowly we build up." (Louise K.)

Teachers work with small groups of students who need preparation for explaining their ideas in the larger group.

> "I guess that small group work with them to kind of preview vocabulary, previewing, practicing circles, having them even put post-it notes or like little stars that they want to share things, ahead of time so that they're almost prepared." (Melina S.)

Students are required to bring their science notes and data so these can be referenced during the discussions.

Teachers described different strategies they employ to help students learn to explain their thinking. At the start of the year, teachers establish expectations for all students to explain their thinking. Teachers employ a variety of strategies such as modeling language, behaviors for

discussions, and fishbowl activities. Students who need preparation with vocabulary and expressing their ideas are supported in a small group before the whole class discussion.

Teaching role: Help students to listen carefully to another's idea. Survey respondents rated at 57% the important of developing students' listening skills by repeating what a peer had just said (see Table 6). In the interviews, all teachers described the strategies they use to help students to listen to each other's ideas. The strategies teachers employ are to practice listening skills by having students talk with a partner and then repeating what the partner said, as well as the modeling how to ask clarifying questions of other students.

Kindergarten and primary grade teachers consistently described listening skills in detail as something they focus on from the beginning of the school year. Often teachers rely on using a routine of turn and talk and share, so that by the spring students put their listening skills into practice in discussions.

> "Some kids when they're five don't know how to listen to someone else and I think the greatest part of that is that when we meet back in the big group I ask them to share what their partner said, not what they said, and in the beginning of the year most of them can't do that so it's a lesson that they learn throughout the six months and then finally, at this point, they mostly can, they would never speak about themselves now." (Louise F.)

All teachers in this study believe that partnerships are useful for students to share and explain their ideas, clarifying through the discussion process. They believe that in a partnership the students help each other learn by supporting each other in listening closely to understand and make sense of their science ideas.

> "The listening piece and what does a good listener look like, what does a good science partner look like, and going through that, modeling for them and talking about, why would that be important to listen to someone else." (Melina S., grade 4).

In a partnership, teachers have students practice with each other then report their partner's ideas to the class as a measure of the listening skills. Fifth grade teacher Elizabeth H. describes this strategy in more detail.

> "A lot of times I will ask them to repeat what their partner had said. So, when you're talking to your partner you need to be ready to turn back to me after and share what your partner has said and really understand it and then I'll confirm with the partner that's what so and so said, did they hear what you were saying. They can confirm or deny it so I can see who's really listening, engaging with the conversation." (Elizabeth H.)

Another strategy teachers model is to help students ask questions of each other in order to understand what someone else means. While some teachers ask questions of students as a prompt to respond to another student's idea, Kindergarten teacher Louise F. described that it is students who ask probing questions of each other in helping each other to clarify their thinking.

> "It does take time to get them to be able to ask good questions, not just questions that are yes or no, but questions that have more detail to them. Not something that you can directly teach everyone easily. So, it takes a lot of modeling and exposure to different conversations." (Louise F.)

Barbara, speaking in the third person, described the rationale she explains to students about why listening and understanding another's idea is an important skill.

> "And if I don't (listen), then I don't know what they've said and I can't say I disagree or agree with you. I can't use anything you've said for my argument because I don't know what it is." (Barbara V.)

Lynda has student paraphrase what they have heard a peer explain.

"I do a lot of work on active listening and paraphrasing is part of that." (Lynda K.)

In sum, listening skills are taught across all grades. Teachers expressed the belief that helping students to express their own ideas and listen to another's ideas are important enough that they use strategies to teach students to listen. The strategies teachers use for teaching listening skills are (1) asking students to repeat what someone else had said, (2) using sentence stems on a chart, and (3) reminding students to listen and ask questions to understand another's ideas.

Teaching role: Help students deepen their reasoning. In science, ideas are based on evidence and how students explain that evidence supports their idea. So, it follows that a key task for the teacher is to continually press students for their reasoning and evidence so that students think about and respond to the ideas and reasoning of other students (S. Michaels & O'Connor, 2015). Two survey items addressed the goal of helping students to deepen their reasoning. These items were to: (1) ask students for evidence to back their claim or idea and (2) ask students for a different idea. Survey respondents rated at 93% the importance of asking students to share their evidence. The one item respondents rated at 100% as important was the routine asking students for a different idea.

Interview participants described teaching students to reason by requiring them to find evidence from their investigation data to support claims.

Teachers described a variety of methods for helping students use evidence to support their science ideas. They require students to bring their science notebooks to the discussion so they can reference their data as they explain their science ideas and use specific qualitative or quantitative data as evidence to support their ideas. Teachers of Kindergarten, First and Second Grade, described instructing students to go home and ask their families to help them look information up on the internet or in books. Teachers used the word 'because' as a prompt so that students supported their science ides with evidence. Melina describes this strategy as a process where the reminder fades as students internalize the need to use evidence to back their ideas and automatically use 'because' over the course of the school year.

> "In this lesson, it was really more about claims and evidence so I really had to use like more sentences and I claim this because or I think this because, so in the beginning, it's like anything else, in the beginning I give them a lot of the scaffolding and then I start to kind of pull that away." (Melina S.)

While the one survey item respondents rated at 100% as important was the routine asking students for a different idea, none described this in the interviews.

Teachers in this study described a variety methods for helping students use evidence to support their science ideas. They require students to reference their investigation data recorded in science notebooks, they use the prompt 'because' so students connect evidence to their science claim, and some teachers ask students to find more evidence from books. While teachers employ a variety of methods to press students for evidence to this claims, they do not ask for other ideas supported by the same evidence.

Teaching role: Help students engage with other's reasoning. Teaching students to engage with other's reasoning and respond to peer's ideas brings in alternate ideas to be

considered. Researchers tell us it is key that students think about and respond to the ideas and reasoning of other students (Sarah Michaels et al., 2008; S. Michaels & O'Connor, 2015). Helping students to engage with each other's reasoning is important for building from intuited ideas towards a more scientific understanding. Three survey items addressed the goal of having students think with others by engaging with other's reasoning: (1) was to encourage students to explain in their own words what someone else means; (2) to expand on another student's ideas; (3) encourage students to challenge each other's ideas; and (4) ask students for a different idea. 71%, of respondents indicated the importance of asking students to explain what someone else said. Similarly, 71% of respondents rated as important asking students to expand on others' ideas. 43% of respondents indicated as important encouraging students to challenge another student's idea.

Similarly, a few interview participants described students building on each other's ideas through student-to-student discourse. To make the discussion productive, students need to listen carefully, understand another's ideas, and be able to clearly articulate their own idea with evidence and reasoning. Teachers who described helping students to engage with each other's reasoning reported the discussions as students teaching each other. Lynda K,'s description articulated the respectful listening and the peer teaching students do in partnerships.

> "I'm making sure that they're hearing both partners. I'm making sure that if a partner's not understanding that they're working to help their understanding instead of judging and I think that I'm looking for kindness and caring. The partners can almost scaffold each other and bring their learning up at any level and making sure that they're just hearing ideas from both sides. And building on each other's ideas. If one idea is not at the same

level, taking them where they are and moving them forward and kids can do that for each other so that they're teaching each other, learning from each other." (Lynda K.)

Barbara's description of challenging ideas captured that of very few interview participants;

"We have these really rich discussions and they're not afraid to speak up and challenge somebody's ideas." (Barbara V.)

Teachers described students politely agreeing or disagreeing, but did not describe critiquing others' reasoning or that students give each other constructive feedback.

While teachers were enthusiastic about students building on each other's ideas, few teachers described helping students to engage with each another's thinking. Although teachers value student-to-student discourse for developing critical thinking skills, they rarely press students to think critically and give feedback to each other on their ideas and reasoning.

Teaching Strategy 4: Discourse as Assessment.

All interview participants described using student-to-student discourse for assessing students' science learning. Of the eight interview participants, six mentioned that they use that information to offer feedback or to plan for the next lesson. Teachers described that the value of student-to-student discourse as an assessment because student thinking becomes visible, teachers establish who is participating, and determine what students know and can do.

First and second grade teacher Melina elaborated on the value for learning because student thinking becomes visible to the teacher.

"It gives me a sense of their thinking and how they're putting things together and so it's like, it's an assessment for me as well. It gives me a lot of information." (Melina S.).

Melina further explained that discourse makes student thinking visible so that the teacher gains more insight into how students connect information.

> "That gives you such a view into their brain and how they put things together and just their thinking is such a good assessment, too." (Melina S.)

Teachers monitor who is participating in the discourse in order to use the data to encourage or help students to contribute. Melina S. described keeping track of who has talked in the discussion;

> "I draw a circle and I draw the four people, like N, S, E, W, and then as people share I put their name in a little X so that I keep track." (Melina S.).

As a result of keeping track of who participated and contributed during discourse, teachers subsequently work with students to encourage or prepare them for participation.

Teachers value discourse as assessment because they can determine what students know and can do. Listening to student-to-student discourse relives teachers from full responsibility leading the students' work, rather they can observe and take notes.

> "I have a check off sheet with me and I'll think, oh they're asking good questions or might need some help, I'll jot down a few notes because I have time to walk around and see them while they're talking with each other." (Louise F.)

Assessment was where teacher artifacts supported and evidenced their use of student-to-student discourse. Teachers had developed several methods of keeping track of anecdotal data from observing and listening in on student-to-student discourse. Teachers can use the data for planning subsequent lessons for the class or for particular groups of students addressing what they may not know or be able to do.

Teachers reported that they found student-to-student discourse valuable as a means to assess student's knowledge of science concepts. During discourse teachers listen to student ideas of science concepts and can determine when student science discussions go astray from the science concept. Katie T. described her use of questions to redirect the focus towards the learning goal.

> "I have to be able to come back and monitor, throwing in an additional question that pulls it back into the direction that it should be heading. I don't want to come in and give the answer, I want to come in and give another way to explore it. So, that they can find the answer." (Katie T.)

Teachers want students to apply what they are leaning to makes sense of new information to grasp science concepts. So, they ask questions pressing students to consider ideas or data the students may have forgotten or need to explore from another angle.

The teachers in this study believe that student-to-student discourse is valuable for assessment because student thinking becomes visible and through observation teachers establish who is participating and determine what students know and can do.

Discussion of the Findings for Research Question Two

There are two findings for this question regarding the teaching strategies teachers use to foster student-to-student discourse for learning science.

Finding 3: Teachers use a limited number of student-to-student discourse strategies to increase student learning in science. Teachers employ a variety of instructional strategies to help students engage in student-to-student discourse productively: (1) student configurations, (2) strategies to help students engage in discourse, (3) deepen their reasoning, and (4) listen to another student's idea. A variety of configurations for student-to-student discourse; partnerships,

small group, and whole class, were used across classrooms. In addition, the use of the configurations varied across grades. The instructional strategies for helping students to engage in productive discourse with peers varied across schools and within grades. These teachers reported the strategies they use to include all students in the discussion, encourage students to listen carefully to another's idea and to question a peer's idea for clarity. Teachers reported they help students deepen their reasoning by requiring evidence to back up claims. Teachers used strategies taken from various sources, workshops, professional development, or other curricular areas, and amended these strategies according to personal preference to foster student-to-student discourse in their classrooms.

Teachers rarely described using strategies to help students think critically about their ideas and those of others'. They rarely press students to think critically, challenging each other's ideas, or to offer alternative ideas for the same evidence. According to current research, considering alternate explanations and challenging another's ideas are the heart of academic discourse that improves student science learning. While teachers value student-to-student discourse for teaching students critical thinking skills, they rarely move beyond asking for evidence to support a claim.

Similar to the teaching of critical thinking skills, teachers developed norms for the classroom behavior and often created and hung posters of classroom norms for behavior in the classroom, they rarely created norms for discussion. The data indicates that teachers understand the value of developing norms for behavior to create a safe learning environment that includes all students and is a safe place to share their ideas. However, they rarely take the time to develop discussion norms. When norms for discussions were created, only one teacher routinely reviewed the norms prior to a discussion. Further, the vast majority of teachers in this study

reviewed norms as a reminder only when the students did not follow the norms. This was true with respect to either behavior or discourse norms.

Finding 4: Teachers use student-to-student discourse as formative assessment to determine student learning in science. Teachers' use of student-to-student discourse as formative assessment for student science learning was an unexpected finding. All eight teachers interviewed described their use of student-to-student discourse as formative assessment because in the discourse between students, student thinking becomes visible. Teachers could establish which students are participating, and determine what each student knows and could do. Teachers described their use of information about student learning to offer immediate feedback or to plan the next lesson. Several teachers had developed strategies for recording individual student's participation in whole class discourse. Two examples are note cards recording each student's developing understanding of science concepts, and recording of class ideas on charts for continual scrutiny as the students revised their ideas to be more scientific. Teachers value student-to-student discourse as a means to formatively assess student science learning and use that information for continuous formative feedback and to plan subsequent instruction.

Summary

Research Question two found that this study's participants use a variety of strategies to help students engage in student-to student discourse to increase learning in science. Three broad sets of teacher responsibilities from the research that help students become effective users of discourse to improve their learning were discussed: (1) configuring the discussions to promote student-to-student discourse; (2) setting norms for class behavior; and (3) teaching specific skills of discourse that align with practices of science. A fourth, unexpected finding was teacher use of student-to-student discourse as formative assessment to improve student learning of science.

Data from survey and interviews indicated there is wide variation in the use of strategies and configurations to help students engage in discourse. Student configurations used most often are partnerships for a quick turn and talk and whole group. Use of these configurations varied from classroom to classroom, between grades levels, and schools. All teachers create norms for behavior with their class, yet they rarely develop norms for student-to-student discourse. The data show while few teachers set norms specifically for student-to-student discourse only one teacher described routine review of discourse norms prior to student-to-student discourse. Teachers employ a variety of instructional strategies to encourage students to engage productively in student-to-student discourse for learning science. While all teachers described helping students to explain and clarify their ideas, to cite evidence, develop listening skills, build on each other's ideas, and their use of discourse as formative assessment, rarely did teachers described helping students to challenge each other's ideas or offer alternative ideas.

Teachers choose to employ some instructional strategies and overlook others resulting in a range of instructional strategies to help students engage in discourse across the district. So, it follows that an inquiry into teachers' perceptions of the factors and conditions that either support or inhibit use of student-to-student discourse for learning science to gain insight into why the variation exists in a district promoting student-to-student discourse in science. The survey and interview data for Research Question 3 will shed more light on these factors and conditions.

Research Question 3: What are the Factors and Conditions that Support or Inhibit Use of Student-to-Student Discourse?

The intent of the third research question guiding this study was to learn teachers' perceptions of the factors and conditions that promote or inhibit their use of student-to-student discourse to increase student learning in science. This question delves into the teachers'

experience learning strategies for student-to-student discourse, the supports they experienced in implementing discourse for science learning, and the inhibitors they faced. The following factors and conditions may impact a teacher's use of student-to-student discourse: (1) professional development received, (2) instructional guidance from curriculum materials, (3) instructional leadership the school, and (4) time.

Two survey items and interview questions dealt with class size and classroom arrangement as potential factors in implementing discourse. Data shows that neither appears to affect teachers' use of discourse.

One survey item dealt with student capacity to engage in student-to-student discourse as a potential factor in implementing discourse. Data shows that these factors have little influence on their use of student-to-student discourse. As discussed in Finding 2, participants described all students as having the capacity to engage in student-to-student discourse.

Two items on the survey asked teachers to provide responses regarding the factors that support their practice of using student-to-student discourse in the science classroom. In addition, responses to an open response survey item where respondents indicated what they would find useful in helping them to guide science talk between students were included and analyzed. Responding to interview questions, teachers often described their experiences in terms of the inhibitors before explaining the supports. At times, interview participants described the supports or the inhibitors as they addressed other interview questions. This data was included in the analysis. Additional follow-up interview questions asked participants for descriptions and anecdotes to describe both their experiences and the conditions that support or inhibit using student-to-student discourse. The summary of these results follows.

Survey item eight required respondents to rank 11 factors that support their practice of using student-to-student discourse in the science classroom. Table 8 depicts respondents' ranking of the factors in percentages by the condensed Likert scale responses.

Table 8

Survey: Degree the Following Factors Support the Practice of Using Student-to-Student Discourse in the Science Classroom

Factors	Often/ Always	Never/ Sometimes
Item 8. To what degree do the following factors support your practice of using student-to-student discourse in the science classroom?		
Administrator expectations	47%	53%
Colleague expectations	20%	80%
Parent expectations	7%	93%
Instructional practice embedded in your current school curriculum	73%	27%
Balancing time between students learning specific content and student-to-student discourse.	87%	13%
Class Size	47%	53%
Arrangement of the classroom	47%	53%
Professional development related to student-to-student discourse	53%	47%
Time allotted for teaching science	73%	27%
Time for planning student-to-student discourse	60%	40%
Time to collaborate with colleagues about the use of student-to-student discourse	47%	53%

The data in the collapsed categories were analyzed and are discussed within the four themes outlined in the introduction to this section: (1) professional development, (2) curriculum guidance, (3) instructional leadership, and (4) time. The interview data is discussed within the same four themes.

Condition: Professional Development

Classroom instruction depends on the capacity of the teacher to solve classroom concerns and coordinate instructional work. School districts hire skillful teachers and build professional capacity through professional development opportunities offered at the school and district levels. Professional development is the continuing education efforts a school or school district provide to improve the effectiveness of its staff. Survey items and interview questions were designed to learn from teachers the kinds of professional development that support them in their use of student to student discourse.

Table 9

Survey: Degree Professional Development Factors Support use of Student-to-Student Discourse

Factors	Often/ Always	Never/ Sometimes
Item 8. To what degree do the following factors support your practice of using student-to-student discourse in the science classroom?		
Professional development related to student-to-student discourse	53%	47%

Survey respondents were nearly evenly split between the two collapsed categories. Table 9 shows 53% of the respondents rated professional development related to student-to-student discourse as a factor in the often and sometimes category.

Interview questions delved more deeply into teachers' experiences with professional development. Their descriptions provided the characteristics of effective professional development.

Professional development characteristics. High-quality instruction in science requires both teaching expertise and content knowledge. Yet, at the elementary school level, many teachers have not had any specialized education or training in science. Teachers described

professional development that interweaves discourse with the science content matched to their grade-level units as effective. First, a theory of learning is required to ground the professional development. Second, the characteristics include modeling instructional strategies with opportunities for all teachers to engage in discourse and science content matched to the grade level taught. Third, the resources teachers described as useful for student-to-student discourse include drawing from the social curriculum and on-line videos of classroom discussions. Finally, the role of elementary teacher science content knowledge is an important component for using student-to-student discourse for learning science.

Theory of learning. Professional development grounded in a constructivist framework actively engages and challenges teachers to think at higher levels through peer discourse. Constructivism holds that all learners create personal models to explain the natural world based on personal experience. So, it is essential to provide learners with the opportunity to construct their understanding of the natural world through interacting with phenomenon and gathering data. The process of constructing knowledge is social. Discourse provides a means to make visible the ideas teachers bring to the content, reconsider these as they make sense of new information, and develop explanations based on generated evidence. Through investigating science phenomenon and engaging in discourse, learners construct their knowledge. In professional development, teachers learn instructional strategies to foster discourse through collaboration with peers.

Instructional Strategies. Teachers believe that professional development experiences should mirror classroom instruction and enable them to transfer to their classroom instruction. All teachers described professional development where the presenter modeled the instructional strategies that fostered teacher engagement in discourse supporting their science content learning

increased their ability to apply these practices in their own classrooms. Seven of the eight teachers in this study believed that learning science content through inquiry with peer discourse meant they could better learn and transfer the instructional strategies to foster student-to-student discourse into their classroom practice. Katie's description exemplifies those of other teachers.

> "I can interact with another adult the way we would like to see the kids interacting. It's just being able to have those kinds of explorations with other adults in a safe environment would be the most rewarding." (Katie T.)

The opportunity to collaborate with colleagues around instruction was described by teachers as supporting their capacity to foster student-to-student discourse. Teachers learn from colleagues in professional development that include discourse. As learners, it is beneficial for teachers to sit together and realize they face similar struggles, and collaborate to find solutions because of similar challenges in the classroom.

These teachers described the instructional strategies in the professional development offered opportunity for collaboration to learn to explain their science ideas, listen carefully to another's idea, deepen their reasoning.

Resources. Two resources were described as supporting teachers learning instructional strategies for student-to-student discourse and transfer to their classroom instruction. These are the social curriculum and on-line videos. Teachers described the lessons in the social curriculum develop trust and taught language they can connect for use in science talks to respectfully agree or disagree. Teachers believe the use of similar language supports teaching students to create a safe environment to respectfully engage in discourse. So, the social learning curriculum used in the schools as supporting student-to-student discourse.

Teachers described the on-line videos of classrooms using student-to-student discourse as resources for their instruction. The two fifth grade teachers with this resource viewed the videos with colleagues to learn to use the instructional strategies with students to foster student-to-student discourse.

> "We had a few professional development days for our [fifth grade science] investigation units in science and the woman who came in provided some resources for us to practice some of the talk moves. I know as a fifth-grade team we've sat down and we've watched a few of the videos, just to give you some examples on how you can be using them and trying the moves." (Elizabeth H.)

Teachers also believed they would benefit from observations of other teachers using science talk because of similar challenges in the classroom teaching. This was particularly mentioned with regard to English Language Learners and Special Education students in the classrooms. Teachers preference is to observe other teachers to learn to better address all students learning needs and implement student-to-student discourse in their classrooms.

These teachers believe that the overlap between the social curriculum behavior and language for discussions and use of the on-line videos to view classroom discourse strategies in use also describe the transfer to their classroom practice.

Science Content. Improved content knowledge supports teachers in better planning for student questions and misconceptions, and real-world applications. Science content learning is understood as a process of development over time. Current research refers to this development over time as a learning progression. When teachers deeply understand the content, they are better able to address student misconceptions through student-to-student discourse.

> "A few years ago, I took the [science] institute and it let me have the experience of being the learner and feeling overwhelmed and feeling like, oh my gosh I don't understand this. So, I was able then reemphasize with my students and understand the learning process a little bit better. I was able to then, I was sort of reminded about cognitive development and how ideas happen and how you change ideas and let go of your incorrect thinking and adopt new ideas. So, I understand the process a little better of what kids go through." (Katie T.)

All teachers in this study described a concern that students may develop misconceptions during the student-to-student discourse. These teachers said they follow-up with the students to correct misconceptions. The commonly described method to address misconceptions was reading books to students followed by a book discussion. However, the three teachers with more professional development in the science content viewed the misconceptions as part of the process of learning and planned ways to address them in subsequent lessons. The lack of science content for elementary teachers, can inhibit effective use of student-to-student discourse because teachers are concerned about students developing misconceptions.

As in all instruction, teachers tend to adapt rather than adopt the instructional strategies they experience. Teachers perceived that while they all use student-to-student discourse, they all do not use it the same way. They recognize this as true even if all teachers have the same training.

> "Because everybody, even though it's a science circle discussion, we all have our own little spin to it and it would be great to observe other teachers doing that." (Melina S.)

While teachers described a desire for opportunities to observe other teachers' practice, and there are systems in place for teachers to do peer observations, the teachers in this study did not describe any experiences with this form of professional development.

Teachers described professional development that interweaves discourse with the science content matched to their grade-level units as effective. This kind of professional development included instructional strategies, resources, collaboration with peers, and increased learning of science content. They describe a desire for observing other teachers practice yet do not appear to capitalize on the opportunity. While teachers may have similar experiences in professional development, they tend to adapt rather than adopt what they experience.

Condition: Instructional Guidance

Instructional guidance takes the form of curriculum guides available to teachers that provide the content expectations and instructional suggestions.

Curriculum guide available to teachers. The curriculum guide available to teachers is intended to be a support. Districts, like the one in this study, provide teacher guides and kit materials for teaching science. 73% of the survey respondents indicated that instructional practice embedded in the school curriculum guide influences their use of student-to-student discourse.

The interview descriptions provided more insight into the survey respondents rating. Melina's description captured the essence of the teachers' perception of their curriculum.

> "I think the science units that we have are very hands on and I think they are very well put together, so I think that lends itself to great discussions." (Melina S.)

However, in the interviews, teachers described having to figure out where to add the discussions in their lessons or throughout an investigation when it was not embedded in the curriculum.

Additionally, teachers described the purpose for student-to-student discourse as sense making as they worked together or to wrap up a lesson or an investigation of scientific phenomena. Six of the eight teachers were not able to reference these supports in their curriculum. Instead, teachers described the curriculum units as lending themselves to using student-to-student discourse.

The exception was the two fifth grade teachers' description of a curriculum unit that includes student-to-student science discussions within the lessons, and adds an explanation to teachers of why to have those discussions. These two teachers noted the difference in curriculum that has the discourse built in and includes language and instruction for teachers on how to utilize discourse with students for learning science. Fifth grade teachers pointed out how their new unit teacher's manual clearly lays out where and why students are to engage in discourse so the teacher knows both where to hold the student discourse and the purpose for the student discourse.

Most teachers perceive their existing curriculum lends itself to include and support student-to-student discourse. However, the two teachers who implemented a science unit specifying where, why, and how to use student-to-student discourse clearly described how the curriculum guide is a support.

Condition: Instructional Leadership

In schools, administrative leadership and support is often cited as an important factor for educational reform efforts (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010). If the instruction of science is to change to align with the vision of the new standards, then instructional leadership is an important factor. Survey respondents indicated the degree that expectations from outside their classrooms are a factor affecting their use of student of student discourse. Teachers noted that they were influenced by expectations of other teachers for how

they teach. Expectations are communicated both overtly and covertly, as part of the culture in a school, as policies and as curriculum. Expectations of administrators, and in particular the school principal, convey to teachers what is important. There was no data showing administrative support for student-to-student discourse from the survey.

To learn more, interview participants were asked to describe the administrative support for student-to-student discourse. All participants described the district elementary science specialist as a non-evaluative support for including student-to-student discourse. Louise captured this belief in her comment.

> "I know that Mary is there if we want to ask for support." (Louise F.)

Louise pointed out that it can be hard for some teachers to receive constructive feedback on changing their instructional strategies, some teachers are more open to change. Louise suggests that administrators who do not have evaluative roles would be best at orchestrating professional development around changing instructional strategies.

> "I don't know how that works for [school] administrators to try to approach that. I think it might come better from the science coordinator than the principal or the vice principal." (Louise F.)

The perception of teachers in this study is that student-to-student discourse is not actively discouraged nor encouraged by school administrators. At the school level, administrator observations and evaluations focus on subjects other than science, which grants the classroom teacher autonomy on science instruction. The lack of administrator expectations regarding the use of student-to-student discourse leaves teachers to decide how it is implemented in their classrooms. As a result, teachers perceive that student-to-student discourse is not expected by their school administration.

However, as a non-evaluative administrator, the science specialist is perceived and knowledgeable and supportive. Kristen's description captured teachers' perceptions of how the science specialists supports teachers in implementing student-to-student discourse.

> "We have a really wonderful science coach, science curriculum specialist, Mary. She has talked a lot about it, about the discourse, and she's really good at pointing you to materials on line, pointing you in the direction of research, and she's spear headed this [new fifth grade] unit that is really based on all the inquiry. So, if all of our science is now going to an inquiry based science, which it is, student discourse is key to that. That's the biggest thing that we have that's benefiting us." (Kristen S.)

Teachers believed a non-evaluative administrator, such as a science coach or specialist who offered direction, feedback, and resources for teachers to implement student-to-student discourse was most effective as a support.

Condition: Time

A factor that can enhance classroom instruction is the amount of time available for student learning (Bryk et al., 2010). 53% of survey respondents rated the degree to which they had time to collaborate with colleagues about the use of student-to-student discourse at sometimes/ never (*see Table 10*). 60% of survey respondents rated the time for planning student-to-student discourse at "often/always". In this study, 87% of the survey respondents rated having the opportunity to make decisions to balance the time between students learning specific content and student-to-student discourse as a supporting factor. In contrast, only 73% of respondents saw the time allotted for teaching science as supporting their use of student-to-student discourse.

Table 10

Survey: Time for Planning and Collaboration

Factors	Often/ Always	Never/ Sometimes
Item 8. To what degree do the following factors support your practice of using student-to-student discourse in the science classroom?		
Balancing time between students learning specific content and student-to-student discourse.	87%	13%
Time allotted for teaching science	73%	27%
Time for planning student-to-student discourse	60%	40%
Time to collaborate with colleagues about the use of student-to-student discourse	47%	53%

Responding to interview questions, teachers mentioned time as a limiting factor for teaching science and for collaborating and planning with colleagues. Time for teaching science is a limiting factor that can impact balancing between students learning specific content and use of student-to-student discourse. Teachers in this study described their belief of autonomy in scheduling and the constraints they try to work around for teaching science using student-to-student discourse.

Scheduling autonomy. Interview participants described their sense of autonomy for creating their schedules in the classroom with the exception of the time students were out of the classroom for scheduled time with specialist teachers for Art, Music, Physical Education, and Library. Teachers believed that being in control of their schedules and the flexibility this gave them allowed them to choose how to balance content learning and discourse.

> "I am totally in charge of my schedule. I have to send them to specialists when they need to go and lunch when they need to go other than that I can do what I want. If I wanted to switch up my schedule, I totally could. (Barbara V.)

When there was not time in the allotted time block for science they found small time slots to include student-to-student discourse. An example was to use the posted morning message so students would discuss the science with each other as they came into class.

> "I'll put it on my morning message. Talk to your science partner about what you think is happening. Is the lake behaving the way you predicted, why or why not?" (Kristen S.)

These discussions were either followed up with a whole class discussion at the start of the day or at the start of the science time in the classroom. Kristen's description exemplified how teachers made time for student-to-student discourse.

Teachers appear to be adept at findings ways to balance the learning of the content and using discourse within the time allotted. They fit in time for discussions in small time slots during the day, set up displays for student exploration with discussion, and believe that if they have control over their schedules, they can find time.

Scheduling constraints. While teachers initially report, they are satisfied with the time they have to teach science, they are required to find other times to fit in discussions. As indicated in Finding 2, this is further evidence that teachers value and would increase the time in order to include effectively student-to-student discourse.

The structure of their schedule determines how often science is taught and how much time there is to teach the science. Teachers usually do not teach science every school day so they believe the continuity of using student-to-student discourse is disrupted.

The belief of the overwhelming majority of participants in this study was that academic supports are scheduled so that students are pulled out for services during science lessons. In the interviews, teachers revealed that students scheduled for support services that remove them from the classroom during science and history lessons. Katie, teaches all subjects to the students in

her self-contained classroom. There are 23 students in the class, with 13 born in other countries, and 7 on Individual Education plans. Support teachers for ESL and for Special Education remove students from the classroom several times through the week. These sessions are scheduled so that students are in the classroom for instruction in literacy and mathematics, but leave during science and history lessons. To emphasize this, Katie stated that one day per week, there is an hour where there are only 11 students in the classroom, and this is one of her scheduled science lesson periods. Katie's experience is similar to all the teachers interviewed.

While teachers acknowledge the supplemental supports for individual students as a factor that could help their use of student-to-student discourse, they describe these as inhibitors for student-to-student discourse for learning science.

Planning for discourse. While participants indicated that while they do have scheduled time to collaborate with colleagues each week, the time was very rarely used to identify strategies to supporting student-to-student discourse. All teachers reported that they had not worked with their colleagues at the grade level or in their school specifically to plan for student-to-student discourse. While teachers described the collaboration between teachers as productive, teachers do not have conversations about student discourse for learning science.

> "But, I don't think, I don't necessarily have conversations about it [student-to-student discourse] with other people." (Barbara V.)

Kristen explained that the closest she and her colleagues come to planning for student-to-student science discourse are informal, after school conversations where teachers discuss the content. While they may notice, what comes up in their own conversations regarding student discussion, they do not analyze and plan for the student discussion.

> "Often in the afternoon [we talk], kind of like trying things out before the kids and then we notice our own conversations, but we have not specifically sat down to plan any kind of accountable talk lesson or anything." (Kristen S.)

Although teachers make time to include student-to-student discourse, they are not able to prioritize their limited planning time to share or plan for the discussions. Rather the planning, if done at all, is left up to the individual teacher to initiate and colleagues to engage in discussion around planning.

After the question regarding planning was asked, and towards the end of the interviews, all participants mentioned collaboration to plan for discourse and discuss instruction would be useful. Teachers added that to establish articulation through the grades they need to have the same information and to work together to establish the goals for each year. They believe opportunities for the staff to collaborate to establish the common language and articulation from grade to grade of student-to-student discourse for learning science are scarce.

Discussion of Findings for Research Question Three

There are three findings for this question regarding the conditions and factors that support and inhibit teachers use of student-to-student discourse.

Finding 5: Professional development focusing on approaches to student-to-student discourse develops teachers' capacity for effective implementation. The teachers in this study believe that effective professional development interweaves discourse with the science content matched to their grade-level units. Teachers who sought professional development described opportunities where they used and learned instructional strategies to implement student-to-student discourse as enabling them to transfer the practice to their classrooms. Teacher collaboration during the professional development was an opportunity for teachers to

makes sense of their ideas and to see the effectiveness of student-to-student discourse. Resources, like the on-line videos of student-to-student discourse, continued supporting teacher learning as they tried the instructional practice in their classrooms. Elementary teachers benefit from developing their science content knowledge because the lack of content knowledge inhibits their ability to address student misconceptions. Professional development that includes and improves teacher content knowledge can build teacher confidence to address student misconceptions. These characteristics in professional development support teachers in implementing student-to-student discourse. Teachers should be reflective practitioners and continuous learners who seek professional development to improve their instructional capacity.

The curriculum guide available to teachers can support teachers' use of student-to-student discourse by helping them to know when and why they are to use student-to-student discourse. While over half of the teachers in this study claim that their curriculum lends itself to using student-to-student discourse, most do not have curriculum guides that include student-to-student discourse. The teachers who implemented a science unit specifying where and why to use student-to-student discourse clearly describe the curriculum guide as a support because the teachers knew when to hold the discussion and the purpose for the discourse. When the decision for the purpose and placement for discourse in the lesson was left to the teachers, they used it to wrap-up a lesson or when they sensed it was useful.

Finding 6: Teachers perceive school administrators' knowledge of and support for student-to-student discourse as beneficial. Teachers in this study perceive the district science specialist or coach as supporting their use of student-to-student discourse. The science specialist was credited with leading the change in the curriculum and instructional strategies. So, she was perceived as having the knowledge and resources to support teachers. Two teachers cited

specific resources provided by the science specialist that supported their implementation of student-to-student discourse.

In contrast, the teachers did not see their building principal, assistant principal, or the district administration as instructional leaders who could help them implement student-to-student discourse. Rather, school administrators are perceived as evaluators and were not as instructional leaders for elementary science. The teachers believe that the administrators have little knowledge of the instruction or content of elementary science because evaluative observations and school-based work focused on literacy. As a result, the school and district administrators are not perceived as promoting student-to-student discourse as an instructional strategy for science or for any content area. While there is an opportunity for school administrators to collaborate with the science specialist to learn and support changing instruction, instructional change is left to the science specialist. As a result, the teachers in this study believed that a non-evaluative administrator in the only person who has developed the knowledge of pedagogy and content to effectively support their implementing student-to-student discourse.

Finding 7: Time and scheduling constraints limit the use of student-to-student discourse in science. There is a tension inherent in current school conditions between the time in the school day and scheduling for all subjects, academic support, and special area subjects. The teachers in this study believe that when they have autonomy to choose to schedule their teaching of science, they can find ways to include student-to-student discourse. When time for including discourse in their instructional block for science ended, teachers described the multiple places in their schedule they managed to insert science discourse.

The overwhelming majority of participants believe there are constraints in the schedule when they did not have autonomy. As discussed in Finding 2, teachers believe that all students benefit from inclusion in student-to-student discourse. The scheduling of the academic supports for ELL and Special Education students results in students leaving the room during science. So, students who would benefit the most from student-to-student discourse are absent. The scheduling for services removing students from the classroom results in a missed opportunity for these students to benefit from the discussions.

Although teachers make time to include student-to-student discourse, they are not able to prioritize their limited planning time to share or plan for the discussions. Teachers may have informal conversations about the discussions in their classrooms, they have not used it as a focus for their professional work. Teachers in this study perceived that they need and should find opportunities to collaborate and establish common language and grade-to-grade articulation for student-to-student discourse in science.

Summary

The factors and conditions that support or inhibit teachers' use of student-to-student discourse are in the four categories: (1) professional development, (2) curriculum guidance, (3) instructional leadership, and (4) time. In general, elementary teachers have little professional development in science content and instruction. Yet high-quality instruction in science requires both teaching expertise and content knowledge. Teachers believe that professional development that interweaves discourse with the science content matched to their grade-level units as effective. The professional development should mirror the experience of the students in the classroom. The characteristics for professional development include modeling instructional strategies so that all teachers engage in discourse and science content they teach. Teachers

believe that resources from the social curriculum on behavior and language, and on-line videos of classroom discussions are useful. Teachers who implemented a science unit specifying where, why, and how to use student-to-student discourse clearly describe the curriculum as a support. Otherwise, the decision of when and why to hold a science discussion is left to teacher. Finally, science content knowledge is important to implementing student-to-student discourse for learning science because teachers can better address student misconceptions and determine students next steps along a progression of learning.

Although teachers describe the characteristics of supportive professional development, only a few teachers have taken advantage of opportunities for learning the instructional strategies that support student-to-student discourse in science. Even the teachers who do find professional development that support their learning strategies, they do not uniformly apply these in the classroom practice. The same can be said for developing the capacity of teachers to effectively apply instructional strategies for student-to-student discourse to their existing curricula guides. While they find that provisioned curriculum that includes student-to-student discourse helpful, they rarely transfer the placement of student discourse across all their units as effectively.

Instructional leadership is an important lever in changing classroom instruction. Teachers in this study perceived that administrative support for the use of student-to-student discourse is most effective from a non-evaluative science leader that brings change to science instruction in the district. The lack of administrator expectations regarding the use of student-to-student discourse leaves teachers with the perception that it is neither supported nor is it inhibited. Teachers are rarely observed teaching science and they do not perceive the school administrators as instructional leaders helping to promote student-to-student discourse or in science. As a result, teachers are left to decide how it is implemented in their classrooms.

Time was perceived to be the great inhibiter for teacher use of student-to-student discourse. Teachers believe that autonomy over their schedule enables them to find ways to balance content learning with time for student-to-student discourse. However, the scheduling of academic supports and special area subjects are two factors teachers have little or no control over. Teachers believe that having little or no control over the schedule inhibits use of student-to-student discourse because some students are excluded. Teachers do have planning time with colleagues, however they did not use student-to-student discourse as a focus for their professional work. Yet, after the interview question was asked regarding collaborative planning, teachers said that opportunities to learn with colleagues is beneficial to implantation of student-to-student discourse in science.

Time and scheduling are complex in schools due to the number of special area time slots for classes, the number of students requiring a range of supportive instruction through Special Education or English Language Learning services, and allowing time for lunch, snack and recess.

Chapter Four Summary

This chapter presented the data collected and analyzed, and the seven findings of this qualitative study to answer the three guiding research questions. The data were presented according to each of the three research questions. Results from the initial survey administered in the spring of 2015 were examined for themes. Subsequent to the survey analysis, a detailed analysis of the interviews was provided. A process of 'in vivo coding' lead to a variety of codes, which were then collapsed into umbrella themes. As in all phenomenological studies, the codes and themes emerged from the data and were not assumed or predetermined. Patterns developed as a result of repeated codes, and then themes emerged. The most frequent themes were carefully examined and the findings were determined through agreement and member checking. Seven

findings were described. *Finding 1:* Teachers value student-to-student discourse as an effective means for increasing students' science learning. *Finding 2:* Teachers would choose to devote more time for student-to-student discourse in science if ideal conditions were provided. *Finding 3:* Teachers use a limited number of student-to-student discourse strategies to increase student learning in science. *Finding 4:* Teachers use student-to-student discourse as formative assessment to determine student learning in science. *Finding 5:* Professional development focusing on approaches to student-to-student discourse develops teachers' capacity for effective implementation. *Finding 6:* Teachers perceive school administrators' knowledge of and support for student-to-student discourse as beneficial. *Finding 7:* Time and scheduling constraints limit the use of student-to-student discourse in science

The findings represent teachers' "lived experience" as they implemented student-to-student discourse in their classes and the supports and inhibitors they encountered. While participants value the instructional strategy, the actual degree to which they value it is evidenced in the various ways they implement student-to-student discourse for increasing science learning. Most of these strategies, listening skills, explaining ideas, and backing claims with evidence, are similar to strategies used across other subject areas. The research-based instructional strategies that are rarely fully applied in classrooms to promote student-to-student discourse are ones that help students to learn critical thinking skills. Also, few teachers develop discussion norms, yet all teachers develop classroom norms and rarely review them before discussions. It was clear that; teachers value student-to-student discourse a means to formatively assess student learning.

The factors and conditions that support or inhibit teachers' use of student-to-student discourse were discussed in four categories: (1) professional development, (2) curriculum guidance, (3) instructional leadership, and (4) time. These teachers believed that specific

professional development and curriculum guides will ensure their implementation of student-to-student discourse. Both scheduling constraints and limited planning time are missed opportunities for school leadership to ensure uninterrupted science teaching time and instructional leadership in applying student-to-student discourse for improving student science learning.

Chapter Four presented the findings for the study and the data supporting these findings. In Chapter Five, these findings are considered and discussed in the context of current research and the possibilities for actions and future research.

CHAPTER FIVE: SUMMARY, DISCUSSION, FUTURE RESEARCH, AND FINAL REFLECTIONS

The final chapter of this dissertation is presented in four sections. The first section presents a brief overview of the study. The second discusses the findings of each of the three guiding questions for the research. This section includes the implications for teachers and curriculum specialists, school administrators including curriculum coordinators and directors, and universities that seek to support the development of teachers who teach science. The third section positions the study in a scholarly discussion and makes recommendations for future research on fostering student-to-student discourse for improving student science learning. The fourth and final section is a reflection on the study as well as possible future work.

Overview

This study sought to provide insight into the perceptions of elementary teachers regarding their efforts to help students use student-to-student discourse for improving science learning. It also revealed the gap between what is recommended in the literature and classroom instructional practice. A growing body of research confirms the importance of student-to-student discourse for making meaning of science ideas and in moving students' conceptual development from intuited ideas towards a more scientific understanding (Barnes, 2008; R. A. Duschl et al., 2007). However, in most elementary classrooms instructional practice in science often does not include student-to-student discourse.

The literature reviewed for this study examined three themes: (1) value of student-to-student discourse; (2) the various approaches educators use to promote the use of discourse as an effective pedagogical strategy for science learning; (3) the factors and conditions that promote and inhibit the use of discourse as an effective pedagogical strategy in elementary science and in the science classroom in general. Discourse is the purposeful talk between students to learn

complex academic content. All students gain knowledge by clearly communicating their ideas, examining diverse ideas, and developing decision-making skills in preparation for students to be adults with the ability to make informed choices as full participants in their own lives (R. Duschl, 2008; R. A. Duschl et al., 2007; National Research Council (U.S.), 2012). Teachers have three broad sets of responsibilities to help students become effective users of discourse: (1) set norms for discourse (Driver et al., 2000; Sarah Michaels et al., 2008); (2) teach specific skills of discourse (Sarah Michaels et al., 2008); and (3) match the discussion type with the content to be taught and learned (Sarah Michaels et al., 2008; Pimentel & McNeill, 2013). The necessary factors and conditions for student-to-student discourse include (1) developing relational trust (Schön, 1983), (2) building the professional capacity of teachers (Ateh, 2015; Braaten & Windschitl, 2011; Windschitl, 2013), and (3) providing curriculum .

Research Design

This qualitative research study used phenomenological methods because those methods best enabled the researcher to arrive at the common themes examining the perceptions of teachers' experiences fostering student-to-student discourse. The research site was purposefully selected because of work the school district had begun regarding student-to-student discourse. The study collected data in two stages, a survey sent to 108 elementary school teachers with 22 respondents and follow-up interviews conducted with eight teachers who volunteered. Interviews took place at the teachers' schools and data were collected that helped answer three guiding questions:

1. To what degree do elementary teachers who teach science consider student-to-student discourse to be an important means to improve learning in science?

2. What are the various instructional strategies elementary teachers of science report they are using student-to-student discourse to increase student learning in science?
3. What are the factors and conditions elementary teachers of science identify as promoting and inhibiting their use of student-to-student discourse to increase student learning in science?

These questions were intentionally sequenced to move from the broad, baseline value for student-to-student discourse toward the specific supports or inhibiters influencing the use of student-to-student discourse in science.

Analysis of the data resulted in seven findings that helped to answer the study's three research questions. These findings are explained in the next section and include implications for teachers and curriculum specialists, school administrators including curriculum coordinators and directors, and universities that seek to support the development of teachers who teach science.

Discussion of the Findings

This study sought data about teacher practice and then explain the gap between the research on student-to-student discourse for increasing student science learning and teacher instructional practice. In the prior chapter, the findings are presented by organizing the data into themes. In this section the interpretive insights into the key findings are used to present a more universal explanation. Similar to previous research, student-to-student discourse in science was found to be a valuable yet underutilized instructional strategy in elementary science (R. A. Duschl et al., 2007; Sarah Michaels et al., 2008). There are three areas of responsibility contributing to the gap between what is recommended and classroom instructional practice. The first is the responsibility of teachers is to keep current in the instructional practices for the disciplines they teach. The second is the responsibility of school administrators as instructional

leaders who can encourage and coach staff in the use of discourse. The third area of responsibility is that of the district administration to promote science learning and the instructional practice of student-to-student discourse.

Teacher Responsibility

Findings 1 and 2 showed that teachers in this study believe student-to-student discourse is valuable and this finding is supported by the indication they would increase the time for it under ideal conditions. It does appear that the degree to which teachers value student-to-student discourse is contingent on their capacity to implement it. Teachers described the value of the instructional strategy, yet they do not have full implementation in their classrooms. Teachers have a professional responsibility to reflect on their practice, determine what they know and need to know and to seek out opportunities to learn and improve their instruction. In this study, teachers who fully implemented student-to-student discourse operated as "pockets of excellence" in their schools. These teachers implemented student-to-student discourse to help students develop critical thinking skills to evaluate science explanations. In contrast to teachers who fully implemented student-to-student discourse, most teachers transferred accustomed instructional strategies for discourse from other subject areas. The prevalence of the use of teacher led turn-and-talk and whole group wrap-up of lessons are examples of transferred strategies.

Time. While elementary teachers work within the amount of time allotted in the school day to teach science and include student-to-student discourse, teachers indicated they would increase the use of student-to-student discourse under ideal circumstances, as shown in Finding 2. It is reasonable to conclude that teachers do value student-to-student discourse because under ideal circumstances they would choose to allocate more time to using student-to-student

discourse. Teachers in this study believe that all students benefit from engaging in discourse with their peers both to develop academic language and science concepts. All teachers found that the scheduling of support services removing students from the classroom during science created a challenge for including all students. When students missed a discussion, teachers found it challenging to replicate the missed opportunity for student-to-student discourse. To offer other opportunities for all students, a few teachers prioritized time in the school day for student-to-student discourse, often rearranging their schedules or making time for discourse by inserting discussions into the morning meeting or other slots during the day. However, most teachers rarely made time for student-to-student discourse outside of the scheduled science lesson time period. These teachers tended to keep to their schedules and expressed their frustration that their allotted schedule did not accommodate incorporating student-to-student discourse.

Instructional strategies. Teachers are responsible for the instructional strategies implemented in their classroom. While there are commonalities between the instructional strategies for discourse across curricular areas, nuanced differences exist between discourse in literature, mathematics, history and science.

All teachers in this study readily described the instructional strategies they used to help students engage in productive student-to-student discourse (*Findings 3, 4, and 5*). Teachers used specific strategies and language to encourage all students to engage in the discussion. Examples are asking students for evidence to back their claim statements and using the word ‘because’ as a prompt for students to provide evidence. They encouraged students to question a peer’s ideas to check for understanding, or to repeat another’s idea in their own words, ensuring development of good listening skills, so students could make sense of their learning and think together about their evidence and explanations. The language and instruction teachers employed are

transferable across the disciplines with the exception of the evidence required in science. In science, evidence is generated by the student in an investigation and then used to back a claim about science knowledge. In a science investigation, however, evidence is generated by a student and then used to back a claim about science knowledge. While all teachers in this study did ask for evidence from the students' investigations, however most teachers relied as much on outside references or student experiences as they relied on evidence found in experiments. This was particularly true when addressing student misconceptions, showing a transference of acceptable evidence from other curricular areas.

While Finding 2 showed that all teachers valued developing critical thinking in students, low implementation teachers rarely described helping students to challenge each other's ideas or to consider alternative ideas supported by the same evidence. Teachers who helped students develop critical thinking skills by asking students for another idea that their evidence could support, asking students to consider, respond to, and challenge each other's ideas were more successful at implementing student-to-student discourse to improve all students' science learning. Instructional strategies to help students develop critical thinking skills were rarely described by most teachers. Often, most teachers described the application of an approach for student-to-student discourse from other curricular areas, particularly literacy. They tended to transfer instructional strategies from other disciplines, as evidenced in the heavy use of turn and talk and the whole group wrap up lead by the teacher. These teachers' personal preferences appeared to guide what strategies were implemented and which they omitted. In short, teachers who helped their students learn how to engage in academic argumentation and develop critical thinking skills were more successful with student-to-student discourse than teachers who did not engage in this practice very.

Teachers who did not use discourse regularly rarely implemented strategies to develop, use and review discussion norms specific to science discourse. Norms set a safe environment for students to share their ideas and build trust within the classroom community. These teachers developed classroom behavior norms for their classrooms, but did not develop norms specifically for student-to-student discourse in science. Having explicit norms informs the whole class of the behaviors and expectations for science discourse. Teachers shared that they reviewed norms only when there were infractions during discussions. Current research holds that reviewing norms with students as a reminder of expectations at the start of their discussion is foundational to productive student-to-student discourse (Sarah Michaels & O'Connor, 2012). While teachers understand the value of creating norms and the importance of agreed upon norms for classroom behavior, few teachers create and review norms for classroom discourse in science.

The need to develop teachers' capacity to implement student-to-student discourse in science was evident in the teachers' desire for a curriculum guide that specified not only the purpose but when to use the discourse. Teachers in this study described the curriculum and concerns regarding addressing student misconceptions. It is hoped that teachers, as the experts on instructing the students in their classrooms, know and are able to apply knowledge to where and why discourse is used in a science lesson. While the teachers described their curriculum guides as adaptable to using student-to-student discourse, when the decision for the purpose and placement for discourse in the lesson was left to the teachers, they used it to wrap-up a lesson or when they sensed it was useful. Yet, research documents that discourse is an effective strategy used throughout a lesson, not simply as lesson conclusion. This is not surprising because it is not typically part of teacher training, and these nuanced and interactive instructional strategies are difficult to specify in curriculum guides.

Formative assessment. All teachers described the use of student-to-student discourse as formative assessment to determine student science learning similarly (*Finding 4*). While they understood that discourse yielded valuable anecdotal data that can be used immediately for feedback to individual students and to plan the next lesson, most teachers relied on memory as to which students understood the science during the class. Additionally, most teachers often described wrapping up a lesson by explaining the science ideas to the whole class or reading informational text.

Teachers who were able to release responsibility to students for sense making and thinking critically in the discussions employed methods for recording anecdotal data during student-to-student discourse. The methods for recording data were readily shown to the researcher. These teachers understood that discourse yielded valuable anecdotal data that could be used immediately for feedback to individual students and to plan the next lesson. Teachers need to have the capacity to turn over the intellectual work to students by having them consider, respond to, and challenge each other's ideas. Katie clearly described this as a challenge for teachers when expressing her perceptions regarding teachers thinking they have to control the discussion.

> "I think the whole entire teaching profession is learning that we don't have to control, but it's in our minds that we do." (Katie T.)

These teachers knew when to insert themselves into the student-to-student discourse to ask questions, and promote further student thinking or when to hold back so students wrestled with their ideas to makes sense of their science explanations. By releasing the intellectual work to students, these teachers could formatively assess and record students' progress towards lesson and unit science goals.

Professional learning. Professional learning is foundational to developing teachers' instructional capacity to implement student-to-student discourse in science. The teachers in this study believe that effective professional development interweaves discourse with the science content matched to their grade-level units. High-quality science instruction requires both instructional strategies and content knowledge. Teachers' deep understanding of science concepts provides the confidence to allow for discussions (Barnes, 1992; Sarah Michaels & O'Connor, 2012). Teachers who understand the science content they teach are better able to intervene when students' have misconceptions (Sarah Michaels et al., 2008). This kind of professional development mirrors the expectation for classroom pedagogy. Through experiencing learning science content with discourse teachers believe they can better transfer implementation of student-to-student discourse into their classroom practice.

Teachers in this study were reflective practitioners who thought about what they knew and what they needed to learn to improve instruction. Where they differed was in seeking out professional development that helped them understand the science content they taught, new or unfamiliar instructional strategies, and transfer of what they learned into their classroom practice. While all teacher descriptions offered insight into the characteristics of effective professional development for student-to-student discourse in science, a few teachers reported they had sought out professional development for student-to-student discourse in science, while most teachers had rarely taken advantage of the opportunities. As a result, the teachers who had sought out professional development did not express concerns with regard to addressing student misconceptions at their grade level. Rather they were secure in their understanding of the science content and had confidence to move students from their misconceptions to a more scientific explanation using student-to-student discourse. While most teachers claimed to be

secure in their content knowledge, they also expressed concerns with regard to addressing student misconceptions and changing science topics.

Teachers in this district had additional opportunities for professional learning through grade level meetings and an opportunity to observe classrooms in other districts. Few teachers described productive grade level or cross grade meetings focusing on instruction. Most used the time to plan field trips or to decide on the topics to teach over the next week. None used the time to plan or discuss their implementation of student-to-student discourse in science. Yet when asked about this in the interviews, most teachers stated that planning and discussing student-to-student discourse in science would be productive work to do with colleagues. Similarly, no teacher reported taking advantage of the opportunity to observe teachers in other districts. Further, they rarely take advantage of the opportunity to observe other teachers' practice.

Most teachers have not independently sought out substantive opportunities to develop their pedagogical knowledge of discourse strategies in science. Rather, these teachers looked to the district or school based administrators to provide professional development to improve their content knowledge and instructional strategies.

It is incumbent upon teachers to seek out professional development that will strengthen their instructional practice in elementary science, both in content and in current instructional strategies. While they value and know that student-to-student discourse in science is effective, teachers can seek out what they need even when it is not provided for them. In this study, four interviewees and four survey respondents had sought professional development in order to improve their teaching in science, while others had not. This resulted in pockets of excellence in the schools rather than communities of practice within the schools (Wagner & Kegan, 2006).

School Administrators' Responsibility

The second area of responsibility is that of school administrators with regard to their role as instructional leaders. Principals and assistant principals are expected to be the managers and the instructional leaders in the schools. Teachers in this study did not see their building principal or assistant principal as taking a leadership role in promoting student-to-student discourse. Teachers perceived that administrators' evaluation responsibilities did not contribute to effective implementation of new instructional strategies and did not believe their administrators took a leadership role with regard to science instruction. Rather, they abdicated in favor of the science specialist, who supports all elementary teachers in the district. The result was that teachers believe administrative support for the use of student-to-student discourse is most effective from the non-evaluative science specialist who is leading change in the district science instruction. However, the science specialist's influence was limited and inconsistent since she does not work in all schools but waits to be invited by teachers.

School administrators, as instructional leaders, have the potential to coach and support teachers to implement new instructional strategies like student-to-student discourse in science. Additionally, school administrators have the responsibility of evaluating teachers' instructional practice. School administrators need to build their capacity by keeping current with changes in content and instructional practices in all curricular areas to help teachers improve instruction. This should be a priority because student learning is at the heart of the work of schools. School administrators can coach and support teachers to improve their instruction practice because when they visit classrooms and observe what happens there. However, when principals and assistant principals take a position in the school, unless they are in a curriculum specific role, the tendency is to relinquish responsibility for instruction to the classroom teachers or subject matter

specialists. The teachers in this study believe administrators are not actively supporting implementation of student-to-student discourse in science.

School administrators are often consumed by the managerial aspects of their work may not stay current with educational reforms regarding developments in discipline-based curriculum and instruction. The reasons for this are out to the scope of this study. However, because school administrators have an additional responsibility of evaluating their teachers, they need to seek out professional learning opportunities to stay current with developments in teaching and learning among the disciplines so they can give substantive feedback to teachers to improve instruction using student-to-student discourse.

Another role for school leadership is making decisions of how the school day is used and prioritizing school time for what is valued. As in *Finding 7*: time and scheduling constraints that limited the use of student-to-student discourse in science reflects the tension between the amount of time available for the school day and the scheduling of supports and special area subjects. Teachers in this study who were high implementers believed autonomy allowed them to find ways to fit in discourse, using morning meeting time or other small periods during the day, yet even they described scheduling of students support services as problematic. Since teachers believe that all students benefit from inclusion in student-to-student discourse, scheduling pull-out services during science robs students of the chance to participate in discourse, an experience so beneficial to them. This is a missed opportunity for school leaders to prioritize and plan for effective scheduling of support services so that the students do not miss important learning that benefits them.

Superintendents' and Central Administration Responsibilities

Finally, the third area of responsibility is that of the district administration to promote science and the instructional practice of student-to-student discourse. Similar to the responsibility of school administrators, school district superintendents and central administrators are expected to be the managers and the instructional leaders for the school district. Teachers in this study did not believe their district administrators took a leadership role with regard to science instruction promoting student-to-student discourse because there are limited expectations for science learning and little or no funding to support changes in curriculum and instruction. Teachers believed that the administrators had abdicated instructional leadership to the district science specialist, a non-administrator, who became the default leader for content and instructional strategy learning in science.

In summary, there are three areas of responsibility for effective implementation of student-to-student discourse in elementary science; district administrative leadership that promotes the foci and instruction valued in the district, school administrators who enforce the foci and instruction through support and evaluation, and teachers who implement the strategies promoting student-to-student discourse. In the end, teachers implement the instructional strategies in their classrooms. Until the district promotes student-to-student discourse as a valuable instructional strategy so school administrators support and expect full implementation from teachers, the use of student-to-student discourse will be dependent on teachers to decide how to implement the strategy. When teachers have opportunities for professional development and are given time to practice the strategy with support, they may value it but are not using it to its greatest extent for its most important reasons.

Implications of the findings

This section provides implications of this study's insights for district and school administrators including curriculum coordinators, specialists and directors, universities that seek to prepare pre-service teachers to enter classrooms, and elementary science teachers. Additionally, it has implications for the wider body of knowledge where other disciplines could benefit from its findings.

District and school administrators. District and school administrators have a responsibility as instructional leaders. District and school administrators' unique position places them in an instrumental position to develop the professional capacity of teachers with regard to instructional practice (Bryk et al., 2010). School administrators need to stay current with developments in teaching and learning, attending conferences to learn and understand the value of student-to-student discourse, collaborate with colleagues and other professionals in the district, engage in reflective practice. Then, as instructional leaders, they can prioritize and foster the conditions to support discourse by prioritizing time and resources, and providing appropriate professional development opportunities including opportunities for collaboration with colleagues and for reflection on instructional practice.

Prioritizing time and resources. District and school administrators play a role in the allocation of time and resources, particularly around personnel resources for supporting students. Policies and guidelines for scheduling support services and use of time on learning are under their prevue. Leadership has an opportunity to develop schedules that provide the appropriate support to all students for learning and balance the time for science to become an engaged and contributing citizenry. Viewing the whole system, prioritizing and balancing models for support with the time available is imperative. While some models favor removal of students for services,

others favor service provisioning within the students' classroom in situ with what happens in the classroom for maximum use of time and connection to the students' classroom experience.

If the use of student-to-student discourse is valued as an instructional strategy for learning science, then it is incumbent on a district or school to promote a clear definition, consistent routines, language, and articulated expectations for all students as well as for the instructional strategies teachers are expected to use. Since all teachers in this study had a similar definition of student-to-student discourse, then they should be able to articulate this clearly rather than through a myriad of descriptions. School districts, and schools within those districts, need to articulate and systemize what is meant by student-to-student discourse so that all professionals are operating with the same working definition and understanding of the term.

Historically decisions on curriculum and instruction have been left to teachers (Wagner & Kegan, 2006). District and school leadership, which includes superintendents, assistant superintendents, school principals, assistant principals and curriculum specialists, also need to promote these instructional strategies with clarity in curriculum, evaluation, and feedback to teachers. Further, it requires the schools as a system to enact a strategic, focused plan that aligns the value of teaching all students with effective professional learning opportunities. Administrators who understand the current practices of science and what the effective use of student-to-student discourse looks like will foster the conditions necessary so teachers implement the instructional strategy successfully.

***Providing appropriate professional development opportunities*.** Teachers in this study value offering all students the opportunity to make sense of new science ideas, and for developing critical thinking skills required by the practices of science and engineering. Yet, the values teachers defined and articulated for student-to-student discourse are not promoted by

consistent instructional practices. Teacher capacity to foster student-to-student discourse in science is dependent on professional development in both content and the instructional practice. Opportunities can be offered within the district as well as making opportunities known from outside the district. Further, by modeling as a learning leader, the school administrator can foster a culture of continuous learning with the staff.

As evaluators of teachers' instructional practice, administrators can give teachers direct feedback to include student-to-student discourse as instructional practice. Teachers in this study were clear that their best support came from the science specialist, a district administrator, who did not evaluate them, and was best able to coach and provide support on student-to-student science. They described supports that included coaching and on-line resources tied to adoption of a new curriculum led by the science specialists. However, the school administrators were described as not having the knowledge to support teaching in science, rather they deferred to the science specialist. Leadership has a clear role in supporting teachers' use of student-to-student discourse as an instructional strategy. To accomplish this, school administrators must seek out and take advantage of professional development opportunities to learn the science content and instruction their teachers are expected to teach and students to learn. Unless administrators have the background to know what to expect teachers to know and be able to do, they cannot effectively support teachers. When administrators can support teachers to implement student-to-student discourse, then the instructional strategies will become fully utilized.

Collaboration across disciplines. Student-to-student discourse is an instructional strategy has transferability across disciplines. Systematizing use of student-to-student discourse is an opportunity for collaboration between all district and school administrators so that instructional expectations in science are coordinated with other disciplines, including Special

Education and ESL, at both the district and building levels. Administrators can guide and support teachers to include student-to-student discourse as an instructional pedagogy, and structure opportunities for teachers to engage in self-study with colleagues for professional learning on the instructional practice. In this study, faculty meetings were perceived as a missed opportunity for teachers to develop articulated goals for students that build their skills in student-to-student discourse.

Universities developing teachers who teach science. Teacher education programs and professional development programs should provide both preservice and in-service teachers with experiences to participate in and learn to facilitate productive science discourse. Students' original contributions are important to productive classroom discourse. However, teachers need to know how to monitor where the student-to-student discourse is going, and should develop some criteria for deciding when the class has reached the learning goal. Teachers need to learn where to insert comments or questions and when to listen. This pattern of joining a discussion and then observing the student discourse is important to promoting productive discourse. Teacher education programs for pre-service teachers that incorporate the instructional strategies for student-to-student discourse include but are not limited to: (1) reflective practice, (2) collaboration with colleagues and other professionals, and (3) observation of other teachers and being observed using student-to-student discourse. Comparable professional development opportunities are needed for in-service educators.

Teachers' professional responsibilities. The teachers' experiences in this study reveals the importance of the alignment between the school district's values and priorities for instructional strategies to increase student learning science. Developing the professional capacity of teachers is the responsibility of the district and of individual teachers. Districts have

the responsibility to promote the professional development learning opportunities that support the districts' goals. Teachers have a responsibility to be reflective learners and think about what they know and what they do not know in order to seek out professional learning to fill the gaps. Teacher professional responsibility includes staying current with developments in education and instructional strategies so that they can select and engage in appropriate professional development opportunities and have the resources to inform and change their classroom practice. The kinds of professional development include but are not limited to: collaborating with colleagues and other professionals, reflective practice, attending conferences, participating in training, joining teachers' associations, observing other teachers and being observed

The teachers' responsibility is to be a reflective, learning practitioner who can determine what they do not know, and then what they need to learn. Teachers must seek out professional development and resources to learn effective strategies for developing student critical thinking skills through student-to-student discourse. Further, by learning how to help students develop critical thinking skills, teachers also learn the nuanced differences between the content areas so they understand the difference and can make clear that difference for their students. For example, a claim in science is based on measurable or observable evidence from an investigation, while one in History or Literature is often based on opinion. While school administrators can foster the conditions to promote changes in teachers' instructional practice to include student-to-student discourse, it is up to teachers to make the change.

Recommendations for Future Research

In this section, recommendations are offered that build upon the results of this study and the research literature supporting the effective implementation of student-to-student discourse. The recommendations are listed and numbered in priority order.

1. **Observing teacher implementation of student-to-student discourse in elementary classrooms.** This study relied on teachers to self-report their use of student-to-student discourse. A study in which teachers are observed actually using student-to-student discourse would add further data on what teachers actually do to foster student-to-student discourse for learning science, which strategies teacher who fully implement student-to-student discourse to develop critical thinking skills, how they use them, and which strategies are most effective in the elementary grades.
2. **Exploring teacher perceptions of using student-to-student discourse from other school districts.** The inclusion of multiple districts would access a larger population. The ability to compare similar and different populations in different districts may be informative to uncover trends across districts rather than confined to one. Additional districts in a study would be helpful in better representing all teachers, rather than those in one district. While this study focused on elementary teachers in a single district, a broader sampling of teachers would increase the study's sample size, validity, and meaningfulness. Further study might enhance the teachers' use of student-to-student discourse to advance science learning for all students. Including these perspectives would broaden the study.
3. **Exploring administrator perspectives on fostering conditions to support teachers using student-to-student discourse in science.** A group that was delimited in the study was district, school and curriculum administrators. Including the perspectives of school and curriculum administrators to learn how these administrators foster the conditions that support elementary teachers' implementation of student-to-student discourse in science would offer more insight into the conditions that are supported and those that are not. This might add

insight into the practices of administrators with regard to instructional leadership and be of value to university programs that train school administrators and superintendents.

4. **Exploring student perspectives on using student-to-student discourse in science.** Student perspectives were not taken into account in this study. Currently there is a trend in research to include the students' perspective in a comparison with teachers' perspectives. Including student perspective would be useful in determining the value students place on peer discourse.
5. **Exploring secondary teacher perceptions of the conditions that support implementation of student-to-student discourse in science.** This study was limited to the use of student-to-student discourse in science at the elementary level. Further study of teachers at the middle and high-school levels could offer insight into the conditions that support implementation of student-to-student discourse in the secondary school levels. The results would be useful to secondary school teachers, curriculum developers, and universities offering pre-service and in-service teacher education as well as school leadership education.
6. **Exploring the relationship of student-to-student discourse strategies used with actual progress in student learning.** Teachers in this study agree with the research that student-to-student discourse is an effective means to increase student learning in science. Discovering if there is a real relationship between using student-to-student discourse strategies and actual progress in leaning science would yield evidence of the effectiveness of student-to-student discourse. The results would be useful to elementary schools, curriculum developers, and universities offering pre-service and in-service teacher education as well as school leadership education.

Final Reflections

The teachers made this study possible, because throughout the interviews as they described their perceptions and experiences in implementing student-to-student discourse, they opened a window into their classroom making visible their instructional practice. They generously gave their time, spending nearly an hour for the interviews, and shared with me the artifacts related to science discourse in their rooms. When listening to the taped interviews, it was evident the interviewee began to trust and openly share their perspective when the inquiry centered on their experiences. This emphasized the value and importance of building relational trust (Schön, 1983) between adults in a school and across a district (Bryk et al., 2010). Trust is foundational to future work with teachers, school and district administrators. Listening to understand others' experiences has the potential to build trust.

My interest in using student-to-student discourse for learning science came from personal professional learning in a physics course integrated with a pedagogical one titled "Listening to Children's Ideas." Through interviewing children about their science ideas, I began to have students engage in discourse with each other to help them make meaning of their science ideas and to move them along toward more scientific ideas. Already familiar with constructivist principles, the importance of oral language for learning, and adding instructional strategies from a social behavior curriculum, I tried to have students begin to manage their conversations. Through conversations with other educators, very few other teachers used discourse in science. Most continued to think of science teaching as transferring information from a text or other source to the students. As I moved into administration and leadership in science for a large school district, I looked for ways to foster the use of student-to-student discourse to improve science learning and read an article on Accountable Talk (Sarah Michaels et al., 2008). My

passion in education to promote teacher use of student-to-student discourse for improving science learning.

At the macro level, school systems are similar to any system. They are composed of parts, which work together by certain rules within a context. The findings in this study indicated three areas of responsibility, central administrators, school administrators, and school faculty, for student-to-student discourse to become common practice. The relationship between these three areas of responsibility needs to work as an aligned system in order to have a cohesive approach to student-to-student discourse. Central administrators communicate what is valued in a school system. School based administrators convey the value through observation and evaluation of teacher instruction. School faculty implement instructional strategies. Development of administrator capacity to know and promote use of student-to-student discourse and teacher capacity to implement the instructional strategy are inseparable. Educational leadership promoting this powerful instructional strategy is necessary for improvement of student learning in science.

In this study, the teacher perception was that administrators do not actively to support their use of student-to-student discourse in science. School and district administrators were perceived as neither understanding science content nor the instructional practice. Since teachers were not evaluated or observed teaching science, administrators sent a message to teachers of what is valued and what is not. This message appears to be at odds with the value teachers place on both science and on student-to-student discourse. There is clearly more investigation that can be done to understand the influence administrators can have on teachers' instructional strategies. Perhaps future work lies in professional learning for administrators to better support teacher use of student-to-student discourse in science in schools.

While I was not surprised to find classrooms that operated as pockets of excellence, I was surprised that the teachers in this study used student-to-student discourse as a means of formative assessment. Most books for teachers on formative assessment promote the use of written work rather than student-to-student discourse. Research tells us that student-to-student discourse can be used as formative assessment, yet teachers have little to guide this practice. Teachers in this study had transferred strategies to listen and, in some cases, to record students' ideas. They used this information to guide students they moved towards articulating scientific ideas.

My perspective regarding my role as an administrator has changed as a result of this study. Throughout the past two and a half years I have been engaged in this study while working as a curriculum coordinator in a school district. As a curriculum leader looking towards current and future work in promoting student-to-student discourse in elementary science, the research process and writing was a productive means to deepen my understanding of the complex system of schools.

Engaging in the process of doing the research is different from reading someone else's research. It was through the steps of doing my own research and listening closely, that I learned to see patterns and identify the themes. Rather than continuing to be in the midst of the dance, my view has shifted to be "on the balcony" (Heifetz, 1994). The findings of this study have shown that the hope of one teacher's excellence in instruction would spread to others was unfounded. I have a better understanding of why there are pockets of excellence spread across the schools; that insight informs future work to support teachers and administrators with regard to science instruction and student-to-student discourse.

A cohesive approach to instructional strategies both within and across schools in a district is valuable work that needs to be undertaken. In order to promote the use of student-to-student

discourse in science within a district, collaboration between the district administrators, including principals, assistant principals, and curriculum specialists and coordinators, is necessary. This collaboration points to future work in professional learning opportunities for teachers and for administrators. Models of professional development can be developed and offered so that teachers and administrators so that they can fully understand the value of student-to-student discourse and develop the capacity to implement effectively.

While there is more to learn about effective implementation of student-to-student discourse to improve science learning at the elementary level, this study has endeavored to provide insight from teachers' perspectives about the value of student-to-student discourse in the science classroom and the supports and inhibitors encountered in implementing it. The responsibility to fully implement the instructional strategy belongs to administrators and teachers alike. Changing instructional practice takes time, patience, and the belief that change can happen.

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Appendix A

Goals and Moves for Science Talk

Goal One Help Individual Students Share, Expand and Clarify Their Own Thinking

1. Time to Think:
   - Partner Talk
   - Writing as Think Time
   - Wait Time
2. Say More:
   "Can you say more about that?" "What do you mean by that?" "Can you give an example?"
3. So, Are You Saying…?
   "So, let me see if I've got what you're saying. Are you saying…?" (always leaving space for the original student to agree or disagree and say more)

Goal Two Help Students Listen Carefully to One Another

4. **Who Can Rephrase or Repeat?**
   "Who can repeat what Javon just said or put it into their own words?" (After a partner talk) "What did your partner say?"

Goal Three Help Students Deepen Their Reasoning

5. Asking for Evidence or Reasoning:
   "Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?"
6. Challenge or Counterexample:
   "Does it always work that way?" "How does that idea square with Sonia's example?" "What if it had been a copper cube instead?

Goal Four Help Students Think with Others

7. Agree/Disagree and Why?
   "Do you agree/disagree? (And why?)" "What do people think about what Ian said?" "Does anyone want to respond to that idea?"
8. Add On:
   "Who can add onto the idea that Jamal is building?" "Can anyone take that suggestion and push it a little further?"
9. Explaining What Someone Else Means
   "Who can explain what Aisha means when she says that?" "Who thinks they could explain why Simon came up with that answer?" "Why do you think he said that?"

Appendix B
E-mail message introduction with survey link

Dear _____,

I am a doctoral student in the Educational Leadership PhD program in the Graduate School of Education at Lesley University, conducting research on the conditions and factors that teachers identify as supporting student-to-student talk in elementary science lessons. The focus of my study is on teacher perceptions. To obtain those perceptions about the use of student-to-student discourse, I will be using a survey instrument, to be completed by elementary classroom teachers teaching science. Your participation, by completing a survey, is very important and I hope that you will agree to complete the survey.

If you decide to participate, you will use the link https://www.surveymonkey.com/s/MNRPXSF to fill out a short survey that will take about 20 minutes. As a follow-up, I may ask you for an interview of about 30 to 40 minutes in duration. Pseudonyms will be used and all identifiers will be removed. All hard copies of data will be stored in locked file cabinets to which the researcher has sole access. Computer files will be on an external hard drive that is password protected.

If you decide to participate in this study, please check the box at the start of the survey. You are free to withdraw your consent and to discontinue participation at any time without prejudice.

The findings from the research will be published in my dissertation. If you are interested in obtaining a copy of the results of the study, please check the box at the start of the survey to indicate interest and a copy of the results will be sent to you using the contact information you provide at the end of the survey.

Please contact me at (617) 332-4098 or at craddock@lesley.edu if you are interested in discussing this study in more detail.

Again, teacher perceptions are essential to this study. Thank you for your consideration and time.

Sincerely,
Jennifer L. Craddock M Ed

Appendix C
Teacher On-Line Survey

Teacher Survey:

1. Years of experience teaching elementary science (*range: 0- 4, 5 – 10, 11 – 15, 16 – 20, 21 – 25, 25+*)
2. How much time do you spend teaching science per week? (*range:* time in minutes: 0 – 30, 40 – 60, 65 – 90, 95 – 120, 120 – 180, 185 – 240, 245+)
3. How do you define student-to-student discourse in science? (*open response answer*)

Directions: Please answer the following questions by rating on a scale from 0% - 100%, where 0% is not at all and 100% is all the time.

4. What percentage of time do you currently use student-to-student discourse in science as a teaching and learning strategy?

0 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

5. Given increased time for science, how much time would you spend using student-to-student discourse?

0 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

6. Please describe how you first learned about student-to-student discourse in science. (*open response answer*)

Directions: Please rank how important you think the following are in student-to-student discourse by circling your choice on the scale. (Never, Sometimes, Often, Always)

7. To what degree do you …

    a. encourage students to challenge each other's ideas

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

b. encourage students to maintain a climate of respect for what others have to say

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

c. encourage students to accept the scientific ideas and theories the teacher presents

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

d. think building trust in your classroom community is important

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

e. think all students have the capacity to engage in discourse

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

f. set and use norms for discussions

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

g. ask students to show listening skills by repeating what a peer said

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

h. ask students to expand on another's ideas

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

i. ask students for evidence to back their claim or idea

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

j. ask students for a different idea

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

k. ask students to explain in their own words what someone else means

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

8. To what degree do the following factors support your practice of using student-to-student discourse in the science classroom?

a. Administrator expectations

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

b. Colleague expectations

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

c. Parent expectations

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

d. Instructional practice embedded in your current school curriculum

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

e. Balancing time between students learning specific content and student-to-student discourse.

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

f. Class Size

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

g. Arrangement of the classroom

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

h. Professional development related to student-to-student discourse

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

i. Time allotted for teaching science

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

j. Time for planning student-to-student discourse

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

k. Time to collaborate with colleagues about the use of student-to-student discourse

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

9. To what degree do the following factors about your students support your practice of using student-to-student discourse in the science classroom?

a. Student prior content knowledge

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

b. Student prior experience with science discourse

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

c. Student motivation

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

d. Student academic ability

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

e. Student English language proficiency

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

f. Student disciplinary/behavioral issues

1_____ 2_____ 3_____ 4
Never Sometimes Often Always

10. On a scale from 1 - 3 (where 1 is most important and 3 is least important), how would you rate the importance of the teacher's role?

    a. To explain science concept to students

    b. To guide and participate in the science discussions

    c. To increase opportunities for students to maintain science discussions independently

11. What would you find useful in helping you to guide science talk between students? (*open response answer*)

You may be asked to participate in a 30 - 45-minute interview based on the results of this survey. Please indicate your willingness to participate below.

☐ I am willing to be interviewed

My contact information is: (*fill in email, school, and phone number*)

Appendix D
Interview Consent Form

Thank you for consenting to participate in the interview regarding your perceptions of the conditions and factors that support or are barriers to student-to-student talk in elementary science lessons. Teacher perceptions are important to this study and your participation is very important.

Pseudonyms will be used and all identifiers will be removed. All hard copies of data will be stored in locked file cabinets to which the researcher has sole access. Computer files will be on an external hard drive that is password protected.

If you decide to participate in this interview, please sign the at the bottom of this form. You are free to withdraw your consent and to discontinue participation at any time without prejudice.

The findings from the research will be published in my dissertation. If you are interested in obtaining a copy of the results of the study, please check the box below to indicate interest and a copy of the results will be sent to you using the contact information you provide at the end of the survey.

Please contact me at (617) 332-4098 or at craddock@lesley.edu if you are interested in discussing this study in more detail.

Teacher perceptions are very important to this study and I hope that you will agree to participate.

Thank you for your time.

Appendix E
Interview Protocol

"Thank you for consenting to participate in the interview regarding your perceptions of the conditions and factors that support or are barriers to student-to-student talk in elementary science lessons. Teacher perceptions are important to this study and your participation is very important."

Organizing question for researcher: **To what degree do elementary teachers of science consider student-to-student discourse an important means to improve learning?**

1. What does the term student-to-student discourse mean to you?
2. Please explain the reasons you consider student-to-student discourse to be an important pedagogical approach.
    a. What do you find are the benefits of student-to-student discourse?
    b. What do you find are the shortcomings of student-to-student discourse?
3. What might you do to make time for student-to-student discourse?
4. Have you collaborated with other teachers to plan the use of student-to-student discourse in science? If so, can you explain?

"The following questions will help me understand your experiences with using student-to-student-discourse to increase student learning in science."

Organizing question for researcher: **What are the various ways elementary teachers of science report they are using student-to-student discourse to increase student learning in science?**

1. What are the various ways student-to-student discourse is visible in your classroom?

2. *Follow up questions if the interviewee has not mentioned.*
    a. What is your role?
    b. How do you teach students to listen and use good reasoning to build their contributions in response to those of others?
5. Describe the most successful experience you have had using student-to-student discourse in science.
6. Describe the least successful experience you have had using student-to-student discourse in science.
7. How do you create an environment that supports student-to-student discourse?
8. How do you develop the capacity of all students to engage in student-to-student discourse in science?
9. Describe the various ways you use student-to-student discourse to increase student learning.
10. How do you monitor student-to-student discourse?
11. How do you determine when to use student-to-student discourse?

"You have thought a lot about this and your ideas are important. Next, I want to know some of your thoughts about the supports and challenges you have experienced in using student-to-student discourse as well as what you might need for further support to continue your own learning."

Organizing question for researcher: **What are the factors and conditions elementary teachers of science identify as promoting and inhibiting their use of student-to-student discourse to increase student learning in science?**

1. What are the factors and conditions that support you in using student-to-student discourse?
2. What are the factors and conditions that you find challenging in using student-to-student discourse?

   Follow up questions if the interviewee has not mentioned administrators as supporting.

   a. What are the various ways administrators currently support your use of student-to-student discourse?
   b. What are the various ways you think administrators could support your use of student-to-student discourse?
3. What would be helpful to you in using student-to-student discourse more frequently?

Appendix F: Sample Interview Vignette

The fifth interview was with Katie, first grade teacher of a looping class who would continue together the next year as a second-grade class. A 24-year veteran teacher, she teaches all subjects to the students in her self-contained classroom of 23 students, with 13 born in other countries, and 7 on Individual Education Plans. Service providers pull students out of the classroom several times through the week. To emphasize this, Katie stated that one day per week, there is an hour where there are only 11 students in the classroom. Katie described the demands of the schedule and curriculum limit the time available for students to work through all their ideas.

Katie describes student-to-student discourse as between students to make meaning as they move from intuited ideas to a more scientific concept. She believes that "beneficial part is that they lead each other down the right track eventually because they seem to know how to go about talking to each other in a way that searches out an answer that makes logical sense to them and they can hold and reapply." She describes this as happening in both formal whole group discussions or informally as the students investigate science phenomena. Katie learned to let go of structuring student discussions and believes that teacher control of the discussions bounds the opportunity for students to learn from peers, and dig deeper in to understanding science concepts, and to become more flexible in their thinking by thinking together with peers.

Katie sought out professional learning where she learned science content by uncovering her own ideas and having them challenged while investigating with other adults to help her change her instructional practice. She adds that "It's just being able to have those kinds of explorations with other adults in a safe environment would be the most rewarding."

Appendix G: Coding Structure

Code Family	**Code**	**Number**
Definition	Definition	24
Factor and Conditions		
	Curriculum includes discourse	4
	Administrative support	14
	Autonomy by schools/ teachers	3
	Changes unknown	11
	Demands	9
	Misconceptions	1
	PD teachers want	9
	professional development	27
	professional development PLC work	10
	Provisioning centrally	5
	Student capacity at grade	5
	Students leave with incorrect ideas	3
	teacher focus on what and not how	3
	teacher not in control	5
	Time	28
	Time- integration with other curricular areas	4
	Unconnected topics choppy curriculum	1
Value		
	ELLS & quiet students	7
	Assessing student learning	9
	Develop critical thinking skills	10
	Make time for	12
	Making sense/ meaning	18
Various ways use discourse		
	Configuration	32
	Teaching students use academic discourse	42
	Assessment	9
	Building trust	9
	Work with another teachers(s)	3