THE NATURE OF ELEMENTARY STUDENTS’ SCIENCE DISCOURSE
AND CONCEPTUAL LEARNING

by

Melissa Y. Parks

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This dissertation was prepared under the direction of the candidate’s dissertation advisor, Dr. Gail Burnaford, Department of Curriculum, Culture, and Educational Inquiry, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the College of Education and was accepted in partial fulfillment of the requirements for the degree of Doctor of Education.

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ABSTRACT

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This qualitative study examined the nature of fifth grade students’ oral and written discourse in relation to their conceptual learning during six science inquiry-based lessons. Qualitative data were collected using small group observations, transcriptions of small group discourse, students’ science notebooks, and student interviews. These data were used to create an in-depth illustration of fifth grade students’ discourse and the impact of that discourse on their science conceptual learning. Findings indicated students spoke in three main discourse classifications during small group inquiries and two of these discourses were also present in the science notebook entries. Findings further indicated gender did not impact the nature of students’ oral or written discourse regarding their conceptual learning. Implications for classroom practice and suggestions for further research in elementary science education are offered.
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I. INTRODUCTION

Educators undertake the responsibility of teaching elementary students the skills they will use as a foundation for future learning. With such great responsibilities, educators seek ways to monitor and improve students’ conceptual learning. Schwab proposed each learning experience include four common places: the learner, the teacher, the subject matter, and the social context (1969). The intersection of the common places affects the conceptual learning of students. Assessing and understanding the conceptual learning of students is a quest for all educators.

The assessment of science conceptual learning, both formally and informally, is completed daily by classroom teachers. Formative assessments may be used informally to monitor students’ progress and provide feedback to help students understand science content. Summative assessments are used more formally to gather data on what students have learned throughout the science program. Over the past twenty years, national efforts to reform science education have advocated a shift from memorization of science facts toward deep conceptual understanding (National Research Council [NRC], 1996). To this end, a variety of tools may be used to investigate and learn about student development of conceptual learning. Those tools may include high-stakes testing, understanding and utilization of scientific thinking and inquiry, and meaningful classroom tasks (Lee & Buxton, 2008). Alternative and performance assessments may
also be avenues by which students’ learning can be studied. Alternative assessments are intended to provide evidence about what students know and can do in a subject matter.

Performance assessments in science yield evidence about what students can do when presented with a problem and provided a laboratory with which to carry out an investigation to solve it (Baxter, Shavelson, Goldman, & Pine, 1992). Present in these strategies is the mix of students working in small groups with peers and working independently to develop conceptual learning.

This study used a socioconstructivist perspective to investigate the written and oral discourse as related to the conceptual learning of grade five students within one science unit. Patterns or relationships existing between the written and oral discourse with respect to students’ science conceptual learning were examined. Within the frame of conceptual learning, discourse similarities and differences by gender were studied.

The participants of the study were observed as they participated in small group, inquiry-based science activities. To meet the purpose of the study, a qualitative case study design was employed. Qualitative case studies are signified by research in which the problem or phenomenon under investigation is limited by a concrete or abstract set of boundaries so as those that limit a study to the confines of a particular school (Merriam, 1998). In this study, students who happened to be members of a particular class at the beginning of the school year predetermined their participation in the study assuming they, or their legal caretaker, signed the study’s consent form. Asmussen and Creswell (1995) determined a case study may be employed when there is a bounded, or closed, system in place. A closed system offers researchers the ability to offer a much more detailed picture of the experiences occurring within the phenomenon under investigation.
Within this qualitative design strategy, there were two main data sets of foci: the oral discourse among peers during inquiry-based activities and the written discourse students created independently following the completion of each inquiry-based activity.

**Research Questions**

The research questions for this qualitative study were:

1. What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities?
2. What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning?
3. What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning?
4. How does gender influence discourse during independent writing and group communication as related to conceptual learning of the science material?

**Purpose**

This study used a socioconstructivist perspective to investigate the written and oral discourse as it related to the conceptual learning of grade five students within one science unit. Relationships between the written and oral discourse with respect to students’ science conceptual learning were examined. Within the frame of conceptual learning, discourse similarities and differences by gender were studied.

The examination of written and oral discourse of fifth grade students as they participated in independent writing and small group science inquiries provided evidence of their conceptual learning. Further, the role gender played as students in their last year
of elementary school enter adolescence and their interpersonal skills begin to develop was also analyzed. Understanding the communication of students and the connection between written and oral discourse and the similarities and differences between boys and girls will contribute to the literature in the area of science education conceptual learning. It is important to investigate the discourse of elementary students because they are just beginning to understand science concepts and phenomena which should be cultivated in elementary school (Jarvis & Pell, 2002). Studies such as this investigation can contribute to the literature that serves to improve students’ conceptual understanding of scientific skills in the elementary years. Further, this study sought to contribute to the literature regarding the role of gender and student group dynamics. Specifically, did gender have any influence either toward enhancement of or hindrance to conceptual learning?

The research questions were grounded in the socioconstructivist theory that communication, written and oral, is an integral part of learning. Based on the work of Vygotsky’s social constructivist theory, knowledge develops from collaborative work with others. Specifically, the study presupposed that the oral discourse between students working in small groups influenced their conceptual understanding (Lemke, 2000). Written discourse independently created in science notebooks provided students an opportunity for personal reflection and expression of conceptual understanding of science (Klentschy, 2006). Using a socioconstructivist perspective allowed for investigation into students’ conceptual learning as they first orally discussed science concepts in small groups then independently composed notebook entries on the same concept.
The role gender plays in discourse as students communicate in small groups stems from the assumption the interpersonal skills students use may impact their conceptual development. Feminists argue gender is an important factor that influences students’ interactions. Cherland (1994) posits that girls favor a discourse of feeling while boys prefer a discourse of action. Discourse of feeling focuses on emotions and compassion whereas discourse of action is focused on logic and action. Not all theorists agree and some recommend using care when labeling gender influences not to generalize into girl talk or boy talk, thus reinforcing gender stereotypes (Evans, 1997). While being cautious to avoid prelabeling or accepting generalizations, it is noteworthy to pay attention to the role of gender as students interact in small groups.

Cohen (1994) outlined several aspects for productive group experiences including the exchange of information, elaborate discussion, equal status, and prosocial behavior. Based on those categories this study examined types of group talk, specifically, sharing of information or elaborate discussions and group status as determined by participation such as, who assumes leadership roles, who is allowed to speak, who is listened to, and who is ignored. Additionally, prosocial behavior, namely cooperation, and being supportive of peers, were examined. In this study, these categories served as guideposts to the nature of elementary students’ discourse while they participated in inquiry-based small group discussions and independent science notebook entries.

The group dynamic plays an important role in the development of conceptual understanding. The position one has within the small group may influence the conversation within the group, specifically regarding one’s suggestions, questions, commands, and challenges (Harre & Van Langenhove, 1991). Based on this concept,
there is a need to examine students’ discourse according to gender. This study examined how gender influenced discourse during independent writing and group communication as related to conceptual learning of the science material.

Vygotsky’s Zone of Proximal Development (1978) suggests discourse students share while working together is beneficial to the conceptual development of particular science topics. Talking in small groups may help students begin to build conceptual understanding, but conversations are not long lasting and students’ memories of discourse can fade. Using written discourse in a science notebook to record concepts and ideas contributes to a permanent artifact that can be reviewed, rethought, and revised as it is created (Wells, 1999). Beyond bridging oral discourse and independent reflection, science notebooks assist students in developing scientific reasoning. The use of science notebooks allows students to record and analyze data then formulate scientific explanations based on evidence, and draw conclusions based on that evidence (Klentschy, 2008). This study used a socioconstructivist perspective to investigate the written and oral discourse as it related to the conceptual learning of grade five students within one science unit. Relationships between the written and oral discourse with respect to students’ science conceptual learning were examined. Within the frame of conceptual learning, discourse similarities and differences by gender were studied.

**Rationale**

Students need to use both written and oral language to perform scientific tasks, to construct new understandings of scientific ideas, and to share their ideas, beliefs, and questions with others (Yore, Bisanz, & Hand, 2003). Elementary classrooms provide many interactive and reciprocal opportunities for students to use oral and written
discourse. These opportunities compliment one another and help the students gain
greater conceptual understanding (Rivard & Straw, 2000).

In the science classroom, students communicate with the teacher and peers
throughout the inquiry process as they pose questions and offer solutions to teacher
posed questions. Some students may use the science notebooks simultaneously during
the discussions while others wait until the inquiry has finished. The written and oral
expression of scientific concepts and phenomena help students improve their conceptual
understanding (Rivard, 2006). To guide students to develop both their written and oral
discourse abilities to improve their science conceptual learning an examination of the
relationship between written and oral discourse is needed.

The use of inquiry-based teaching was selected for this study. The teacher-
participants were familiar with inquiry teaching based on classroom experience and
familiarity with accepted best practices for elementary education. For this study, inquiry-
based teaching falls under the best practice concept because it provided developmentally
appropriate, student-centered experiences while providing opportunities for social
collaboration and reflection (NRC, 1996).

The National Science Education Standards (NSES) support the necessity of
discourse and inquiry in the science classroom as an elemental part of science conceptual
learning. “An important stage of inquiry and student science learning is the written and
oral discourse that focuses attention of students on how they know what they know and
how their knowledge connects to larger ideas beyond the classroom” (NRC, 1996, p.36).
The NSES further recommend:

Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanation, constructing and analyzing alternative explanations, and communicating scientific arguments (NRC, 1996, p. 105).

Conceptual understanding of science topics is enhanced with hands-on inquiry-based experiences. “Robust understanding comes from seeing the same concept from multiple perspectives and representing and using them in multiple ways, thereby developing connected webs of understanding rather than rote memorization of facts and procedures” (Darling-Hammond & Bransford, 2005, p. 216). Understanding the discourse between students as they participate in small groups is critical for understanding how elementary students develop and refine science conceptual learning.

Discourse is an important part of science conceptual learning and numerous studies have focused on types of talk that influence learning (Gee, 2005; Lemke, 1990; Paratore & McCormack, 1997). The roles students undertake as they interact and communicate with peers impacts their learning. Barnes (1988) classified discourse into two types, exploratory and presentational. Exploratory talk involves collaboration regarding the consideration and arrangement of ideas. Exploratory talk may be hesitant and contain inexplicit utterances that help the speakers represent themselves and what they know while allowing that understanding to be fluid and to change based on feedback from the group. Presentational talk involves the reporting on discoveries. Presentational talk occurs when students are called on in class to communicate their understanding and may lead to having a “right” answer. Because of the nature of the
science activities occurring during the study exploratory, rather than presentational, was the targeted discourse.

Within the discourse field, the role gender plays within peer discussions is significant. Numerous studies have indicated males dominate discussions in classrooms (Mewborn, 1999; Shakeshaft, 1995; Thorne, 1993; Tindall & Hamil, 2004). Conversely, Harre and VanLangenhove (1991) argue the positioning within small groups is fluid and may change dependent upon the topic. Either perspective indicates a need for greater examination into the learning taking place in elementary science class, specifically within small groups and how that learning is mediated by the capacity and nature of discourse. Learning as a part of a community is integral to science conceptual understanding. Power relationships, age, class, gender, and language affect learning within a community (Lemke, 2000). Examining the roles students select and the manner in which they accept and respond to the roles during science inquiries must be examined.

Science notebooks allow students to explore their thinking as they describe, explain, formulate, persuade, and question scientific experiences. Writing allows students to have a deep understanding of science content as they develop and refine their ideas (Kotelman, Saccani, & Gilbert, 2006). For this study, student science notebooks were classified into two parts, a free response and a guided response drawn from the work of Klentschy involving seven specific response areas (2008). The first part of the science notebook consisted of a five-minute free form reflection, a Quick Write. During the Quick Write, students were asked to tell about the inquiry. Allowing students to freely write about their likes, dislikes, and learning or hindrances to that learning in an
academically nonthreatening way, the science notebooks provide a window into the students’ world (Mills, 2003).

**Significance of Study**

A socioconstructivist framework is the overarching theme of the inquiry-based science class. The socioconstructivist theories of Vygotsky indicate learning is enhanced when students have the opportunity to talk about their ideas with others. Recent additions to the small, but increasing, body of research and practice in science teaching indicate language is essential for effective science learning (Winokur & Worth, 2006).

The study was an examination of the discourse among elementary students and the independently written discourse of individual students pertaining to specific science conceptual learning. As students become familiar with the process of sharing and debating with their peers in small group discussions, they will increase their scientific literacy (NRC, 1996). Of all the language modalities, reading, writing, and oral, the latter is the least discussed in science education (Winokur & Worth, 2006).

This study was significant because of the examination of two closely related ways of conceptual learning, written and oral discourse. Binding the two concepts together was the role gender played as students enter adolescence and their interpersonal skills begin to develop.

**Definition of Terms**

The following definitions were used in the study.

*Assessment*: Assessment was important to the study as a range of processes that access both verbal and written evidence of student knowledge and understanding. For the purpose of this study, assessment was defined as “the collection of information, both
quantitative and qualitative, obtained through various tests, observations, and many other techniques, that is used to determine individual, group or program performance” (Doran, Lawrenz, & Helgeson, 1994, p. 388). In the study, the researcher used both written and oral discourse to assess students’ conceptual learning.

*Conceptual Learning:* Elementary students enter the classroom with many ideas, beliefs, and theories. For this study, it was necessary to define conceptual learning as the “ideas formed while students make sense of their world” (Carin, Bass, & Contant, 2005, p. 25). Conceptual learning contains three main components; concepts, principles, and theories. For this study, the following definitions of each were applied in the discourse analysis.

*Concepts* are “ideas derived from experience around which new experiences may be organized,” *principles* are “generalizations about relationships among concepts,” and *theories* are “imaginative networks of facts, concepts, principles, and assumptions that serve to explain observations” (Carin, Bass, & Contant, 2005, pp. 25–26). These components were based on the framework of science benchmarks outlined by the NSES and the Next Generation Sunshine State Standards (NGSSS).

*Discourse:* Students have various ways to communicate with peers and adults. For this study, the focus of discourse involved both written and oral representation of conceptual learning. Gee (2005) explains seven realities within the spoken or written discourse: significance, activities, identities, relationships, politics, connections, and knowledge. Lemke defines discourse as, “social activity of making meanings with language and other symbolic systems in some particular kind of situation or setting” (Lemke, 1990, p.8). For this study, discourse was classified as the words, deeds, and
interactions that allowed the speaker and writer to situate meanings within a particular context (Gee, 2005).

Discourse Analysis: Discourse analysis has both a narrow view, focused on the word or sentence, and a broader view focused on the social meaning of words and sentences. This study focused on the latter and defined discourse analysis as, “the analysis of linguistic behavior, written and spoken, beyond the limits of individual sentences, focusing primarily on the meaning constructed and interpreted as language is used in particular social contexts” (Bhatia, Flowerdew, & Jones, 2008).

Elementary: For the purpose of this study, elementary refers to children between the ages of five and eleven years old attending school between the grades of Kindergarten and fifth grade.

Gender: For the purpose of this work, gender refers to sex-based male and female categories. Gender, rather than sex, is used in this work due to its accepted reference by anthropologists to social categories whereas sex has a more biological connotation (American Heritage Dictionary, 2000).

Groups: For the purpose of this study, groups referred to teacher created teams of four to six students that shared materials and ideas while completing science inquiries.

Notebook: Science notebooks were important to this study as tools for students to record their thoughts, questions, and discoveries during science inquiries. For this study, notebooks were defined as, “a collection of student writing and drawing that reflects inquiry experiences that occur in the classroom” (Aschbacher & Alonzo, 2006, p.182). In some research projects, the term journal is used interchangeably with notebook. This study used the term notebook when referring to both a scripted teacher directed prompt
to use notebooks throughout the science lesson and an unrestricted free write at the end of the lesson.

Small Group: Group size and make-up varied by classroom. For this study, small groups focused on the task and delegation of authority, rather than rewards and group goals and were defined as “students working together in a group small enough that everyone can participate on a collective task that has been clearly assigned...students are expected to carry out their task without direct and immediate supervision of the teacher” (Cohen, 1994, p. 3).

Theoretical Framework

This research study aimed to examine the conceptual learning of fifth grade students as they engaged each other in science based dialogs originating from guided inquiry-based activities. Several theoretical frameworks supported this work.

Socioconstructivism

In the social constructivist perspective, thinking and knowledge develop from personal interactions in social contexts. Within this frame of reference, it is believed collaborative work, such as small groups in the elementary school classroom, may serve as a tool for transforming the results of interactions into knowledge. The Zone of Proximal Development suggests students’ independent ability to understand concepts is increased when provided the opportunity to communicate with others that possess more or different knowledge and understanding than the individual (Vygotsky, 1978). This study examined the nature of students’ oral discourse as they completed science inquiries in small groups. As students completed science inquiries the role of gender as related to communication and conceptual learning was examined.
Nearly a century ago, Dewey asserted the importance of experience in the education of American youths. Dewey stressed science was not about mundane activities, but rather the experience created by the activity. “Only by taking a hand in the making of knowledge, by transferring guess and opinion into belief authorized by inquiry, does one ever get a knowledge of the method of knowing” (Dewey, 1910, p. 124).

Piaget, a forefather of constructivism, also focused on the fluid nature of scientific conceptual development. “Scientific knowledge is in perpetual evolution; it finds itself changed from one day to the next” (Piaget, 1968). He continued, having conceptual learning is not about copying it, but rather acting on it experimentally. In today’s curriculum, Piaget’s theory supports the use of inquiry-based instruction as a key to conceptual understanding over rote memorization of facts and figures. When science curriculum combines the socioconstructivist theories and a strong, research based science curriculum, the constantly evolving conceptual development of students may be enhanced. This study used lessons created on the 5E inquiry format to examine the nature of elementary students’ discourse as they worked in small groups to complete selected lessons. Using that format, the conceptual learning of students as they participated in science lessons was examined.

5E Inquiry

The 5E frame for inquiry-based instruction is based on the work of Roger Bybee (1995). The 5E inquiry-based theory is an instructional model that incorporates hands-on activities and student discussions in small groups. Inquiry-based science activities allow students to combine personal ideas and experiences with those of their classmates in an
environment where they feel free to take risks without fear of ridicule or taunting (Alkove & McCarthy, 1992). The active role students assume in the inquiry process is a key piece to their conceptual understanding. “Learning science is something students do, not something that is done to them” (NRC, 1996, p. 20). The NRC further emphasizes communication is a critical aspect of the inquiry process. For students to maximize their learning during the inquiry process, they must be able to articulate their thoughts as well as actively listen and respond thoughtfully to their classmates. Providing students the opportunity to take ownership of their learning by expressing their ideas facilitates understanding of the topic at hand in a manner that makes sense to each individual (Alkove & McCarthy, 1992). This study investigated the nature of students’ discourse, both oral and written as they completed lessons created with the 5E format. As students completed the lessons, the influence of gender on both oral discourse in small groups and independent discourse as students wrote in science notebooks was examined. Evidence of conceptual learning was sought through both discourses as students explored, made and disputed claims based on scientific principles, and reflected to draw conclusions about scientific processes.

**Gender in the Elementary Classroom**

The last year of elementary school can be a trying time for students. Girls and boys begin to focus on and perhaps change their interactions with classmates. Some students become aware of gender stereotypes that may be classified under the girls are good and boys are bad illusion. Gender roles become more apparent as boys overtly and repeatedly test boundaries set by teachers and peers while girls test those boundaries in more covert and careful ways (Baker-Sperry, 2006). For these reasons, some student
groupings promote more effective avenues for conceptual learning than others for students at this age.

Making sense of the interactions of students necessitates a gender lens. Thorne (1993) described the process and repercussions of crossing gender lines within the elementary school. Girls are sometimes met with resistance, and may be called tomboy, particularly as they reach adolescence. Boys are rarely granted a socially acceptable means with which to cross gender roles without the fear of humiliation and chastisement from peers. Green (1987) identifies this process as the sissy-boy syndrome where stigma is attached to a boy who is interested in items defined as for girls. Calabrese-Barton (1998) has examined gender and science education and suggested understanding the link between gender and science might lead to classroom interventions that balance existing unequal relations in science learning environments.

While seeking to understand the role of gender in elementary science lessons, the grouping of students must be addressed. Cohen details productive small groups must be based on conceptual objectives that include, “learning for understanding, grasping an abstract idea in such as way the student can recognize and work with the concept in a variety of settings, taking multiple perspectives on a problem, learning to communicate abstract ideas orally and in writing” (Cohen, 1994, p. 63). Cohen further suggests teacher created groups of four or five students. Avoiding grouping friends together promotes a tone of work rather than play, which allow students to focus more closely on the task at hand (Cohen, 1994). It was the intent of this study, using gender as an anchor, to investigate the conceptual learning of students as they participated in small group inquiries and shared their ideas orally and independently in their science notebooks.
Discourse

There are multiple approaches to discourse and discourse analysis. Van Boxtel and Roelofs (2001) and Gee (2005) have suggested two main types of discourse and analysis, those focused on applied linguistics and those that intertwine what is said with the speaker’s actions, interactions, gestures, and tools with the goal of gaining evidence and understanding for a particular event. The mingling of discourse and tools used in science lessons, as detailed in Van Boxtel and Roelofs’ research on fifteen year old students using concept maps and collaborative learning in a physics class, was the focus of this study. This study investigated the nature of students’ talk and any patterns that emerged between written and oral discourse as they completed science inquiries. During the inquiries students manipulated tools, shared supplies, discussed and debated ideas on the topic of force and motion. Consequently, studying the discourse as it intertwined with actions and interactions with peers was the most useful for the study.

Limitations

This case study had several limitations. The case study took place in one public elementary school in a suburban area of southeast Florida and used student participants form three classrooms. The study took place over a four-week period in the fourth quarter of the 2009-2010 school year.

One researcher, a fifth grade classroom teacher at the site, gathered, analyzed, and drew conclusions from the data. There were several issues that must be addressed because only one researcher conducted the study. First, personal bias, assumptions, and perspectives must be acknowledged. Because only one researcher conducted the study, reflexivity was present throughout. Patton (2002) describes reflexivity as examining
what and how the researcher knows what she knows. By acknowledging and examining personal perceptions and biases the findings have increased validity and reliability. Three classroom teachers, with varying experience levels, participated in the study. Finally, a sample of convenience was used because the student participants were members of the school where the researcher was a classroom teacher.

**Delimitations**

The population of the study consisted of three fifth-grade classrooms. All three of the fifth grade classrooms had random student populations assigned prior to the school year. Two classrooms at the site were excluded from the study. One of the excluded classrooms contained gifted and high achieving students that must take and pass an intelligence test to be part of the class. The second classroom was excluded because it was the class of the researcher.

The entire force and motion unit selected for this study contained six lessons. For this study, all six lessons were selected because of their objectives that promoted small group interactions. This unit was purposefully selected for two reasons. First, the unit is part of the curriculum recommended by the county. The administration of the school site expected all teachers to follow the county curriculum guidelines. Second, the selection of lessons within the force and motion unit allowed students regular opportunities and responsibilities to collaborate with peers due to the construction and testing of various contraptions that focused on key force and motion concepts such as gravity, friction, potential and kinetic energy.

From each of the selected classrooms, one group of four to six students was randomly selected. The selected group was observed for all six inquiries. The group
was voice recorded during each inquiry. Student participants were interviewed after the second and last inquiry. Students’ science notebooks entries for each lesson were analyzed.

The three classroom teachers that participated in the study agreed to use a scripted lesson for each of the force and motion lessons. Each lesson plan included a guiding key question that began the inquiry followed by background information for the teacher and questions to ask the entire class to guide progression of the lesson.

**Summary**

This study focused on written and oral discourse in an elementary school classroom. This chapter contained the background for the study, the purpose and rationale for the study, limitations and delimitations for the work, conceptual framework, and a list of terms applied in the study. Chapter 2 reviews literature on written and oral discourse, science conceptual learning, and gender in the elementary classroom. Chapter 3 describes the methodology used in the study. Chapter 4 shares the results of the study. Chapter 5 offers conclusions, recommendations, and suggestions for further research.
II. REVIEW OF THE LITERATURE

The science curriculum has experienced support, criticism, reform, and reconstruction during the course of its development. Over a century ago the study of science was under scrutiny and subject to reform (Kliebard, 1987). In a partial effort to make the science curriculum unified the subject of General Science emerged in the 1920s. From the 1920s the goals of science curriculum have been frequently examined, debated, and modified (Kliebard, 1987). Congress created the National Science Foundation (NSF) in 1950 as an independent federal agency “to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense” (NSF, 2008). From the 1950s, with the establishment of the NSF, inquiry-based instruction has been strongly suggested as the way to improve science instruction.

Throughout the various versions of curricular reform a constant theme, supported by the National Research Council (NRC), called for increased scientific literacy. Scientific literacy is “the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity” (NRC, 1996, p. 22). Inquiry-based instruction is one way to assist students in becoming more scientifically literate. During the inquiry process, the study of science is a collaborative endeavor dependent on the sharing and debating of ideas (NRC, 1996). This study used a sociocultural perspective to investigate the written and oral discourse as it related to the conceptual learning of grade five
students within one science unit. Relationships that existed between the written and oral discourse with respect to students’ science conceptual learning were examined. Within the frame of conceptual learning, discourse similarities and differences by gender were studied.

The practice of reviewing and modifying science teaching and learning has been in existence nearly as long as the subject itself. This chapter will review the literature regarding students’ oral and written discourse while participating in small group inquiries and evidence of students’ conceptual learning. The review will focus on studies within the last twenty years focused on elementary school students’ science learning. This review purposefully selected works on: students’ science conceptual learning, inquiry-based science experiences, small groups, student discourse, science writing, and gender.

This study examined the nature of elementary students’ oral and written discourse during science class. Elementary students’ construction of science conceptual learning during inquiry-based science activities is the overarching theme of the review. Embedded in constructivist theory, inquiry-based instruction is part of the curriculum supported by the NSES and within that curriculum peer discussion and collaboration is integral. Within the context of students’ development of science conceptual learning communication among peers was examined. As students are involved with inquiry-based activities, they regularly engage each other in some form of communication. Upon completion of an inquiry, students are expected to draw on the experience and be able to articulate their learning in either oral or graphic form so the teacher may assess learning
both formatively and summatively. Evidence of conceptual learning, as reflected in writing in science notebooks and in oral discourse, was examined in the study.

Since the inception of No Child Left Behind (NCLB), high-stakes testing has become part of the American educational experience (U.S. Department of Education, 2009). Consequently, educational standards, lessons, and assessments have been created, modified, and implemented throughout the country. The Florida State Board of Education first approved the Sunshine State Standards in 1996 as a means of identifying academic expectations for student achievement in Florida. The Sunshine State Standards were created to prepare Florida’s students to “effectively engage, communicate, and compete globally with students around the world. Florida’s standards incorporate important skills such as critical thinking, problem-solving, creativity, innovation, collaboration and communication” (FLDOE, 2008).

In 2008, Florida adopted newly revised Next Generation Sunshine State Standards (NGSSS). The NGSSS arrange the grade five curriculum into Big Ideas: (a) the practice of science, (b) the characteristics of scientific knowledge, (c) Earth in space and time, (d) Earth systems and patterns, (e) properties of matter, (f) changes in matter, (g) forms of energy, (h) energy transfer and transformations, (i) forces and changes in motion, (j) organization and development of living organisms, (k) diversity and evolution of living organisms, (l) interdependence. The new science standards are the latest attempt to respond to calls for clarity, coherence, and minimal redundancy within the curriculum (FLDOE, 2008). This study focused on students’ conceptual learning as they completed inquiries within the force and motion strand of the NGSSS.
According to the Florida Department of Education (FLDOE) website, the force and motion strand of required standards is annually assessed using both multiple choice and short response questions on the state required Florida Comprehensive Assessment Test (FCAT). During the 2010 FCAT, despite the new standards, 58% of fifth grade students at Dolphin Elementary, the site of this study, earned a score of proficient, level three or higher, on a five-point scale (FLDOE, 2010). During the same school year, 48% of Broward County fifth grade students scored at the proficient level. To give students the tools they need to become scientifically literate and demonstrate their conceptual understanding in various forms, including oral and written discourse and standardized tests, an examination of students’ conceptual learning was warranted.

This study used qualitative methodologies to describe the interactions in three fifth grade classrooms. Denzin & Lincoln (2005) describe qualitative research as a situated activity that locates the observer in the student participants’ world and attempts to make sense of the phenomena based on the student participants’ meaning of observed events. In this study, the researcher examined the nature of the discourse of fifth grade students in their world of an elementary school classroom. The study focused on emerging themes based on data collected in a natural setting, the elementary classroom. Themes were based on inductive data analysis shaped by the collection and analysis of data during the study.

Creswell classified four worldviews that shape qualitative research: postpostivism, constructivism, advocacy/participatory, and pragmatism (2003). This study focused on social constructivism, which Creswell described as seeking understanding of a situation based on the views of the student participants as they are
socially constructed. That is, the participants in this study, fifth grade students’, content learning taking place in situations that are based on interactions with others.

Erickson (1986) advocated that case studies provide depth, insight, and perspectives that are useful in various contexts. More specifically, researchers in science education have found case studies helpful in understanding the complexities of science classroom practice (Appleton & Asoko, 1996; Arnold & Millar, 1996).

Van Zee completed several studies focused on student discourse during science classes ranging from elementary students to preservice teachers using qualitative methodologies (2001, 2000, 1997). She found the qualitative research approach enabled the data to show detailed excerpts of discussion between student participants. Those excerpts allowed for in-depth analysis of discussion related to science learning. In the study, qualitative research, specifically discourse analysis, was used to develop a complex understanding of student discourse in the fifth grade classroom.

This chapter begins with a synthesis of studies on science conceptual learning among elementary school students. Second, the review discusses inquiry-based instruction. Third, it turns to student group work, gender in elementary classrooms, and then to student discourse. Finally, the review concludes with writing for conceptual understanding. The active construction of knowledge by students working in small groups is interwoven into all sections of the review. The focus of this chapter is to synthesize research pertaining to student construction of scientific conceptual learning during discourse with peers and independent reflection as recorded in science notebooks.
Science Conceptual Learning

Students enter the elementary classroom with ideas and experiences that determine their readiness to learn. Connecting the everyday experiences of students to their classroom environment is the responsibility of the classroom teacher. Students must be given opportunities to make meaningful connections to classroom learning and everyday life. One way students can enhance conceptual learning is by working with peers. Students working in small groups may discuss, challenge, and argue as they are actively involved in developing their conceptual learning both orally and graphically in their science notebooks. Conceptual learning is the understanding of what lies behind or under performance in concrete social practices (Schoultz, Saljo, & Wyndhamn, 2001). From a socioconstructivist perspective, conceptual learning is mediated in different ways in different social settings. There is not only one way for students to gain conceptual understanding, rather; their reasoning and performances are best understood within individual contexts (Schoultz, Saljo, & Wyndhamn, 2001). This study sought to examine the nature of students’ discourse as well as any emerging patterns between oral and written discourse as students participated in science inquiries designed to increase their conceptual understanding of force and motion.

Based on a collection of disciplinary and epistemological schemes, Deng (2007) proposed three conceptions of knowledge: disciplinary, practical, and experiential. Disciplinary conception of knowledge explains human knowledge in terms of canonical academic knowledge found in various intellectual disciplines. Practical conception of knowledge details knowing what to do in practice and action. Finally, experiential conception of knowledge focuses on the social, cognitive, dispositional, and practical
elements of making sense of the phenomena of everyday life (Deng, 2007). In this study
elements from the practical and experimental conceptions of knowledge were evident as
students worked together in inquiry-based science activities.

Leach & Scott (2003) organized a meta-analysis on current trends in student
learning in science education. By considering theoretical tools available in literature,
Leach & Scott argued the benefits of combining two broad strands of student conceptual
learning, specifically individual and socioconstructivist views. By following the shift
from Piaget’s genetic epistemology to Vygotsky’s learning and meaning-making during
social interaction, they argued insights on students “mental structures” are not enough to
explain how students learn science (Leach & Scott, 2003, p. 93). Rather, they point out
learning science is optimized when the learning processes of social-interactive and
personal sense making are combined in such a way classroom discourse connects
conceptual tools, epistemological framing, and scientific reasoning to assist in the
development of conceptual learning.

Students’ interest in and responsibility for making meaning out of classroom
experiences is a key component of inquiry-based instruction. The NSES stress the need
for students to learn science concepts by actively engaging in inquiries that are
interesting and important to them (NRC, 1996). Focusing on the child is also a central
theme of the Progressive movement of education. As outlined during the progressive
education movement, the importance of the learner’s participation in the formation of
purposes that direct activities in the learning process is critical (Dewey, 1938). While
students work to discover and understand scientific concepts, it is essential they are
aware of their interactions with others and how those interactions can help or hinder the
learning. Students must be responsible for their actions so they do not impede their, or their classmates, development of conceptual learning during an inquiry experience.

Students require guidance from their teacher on how to successfully interact with their classmates and cultivate conceptual learning. Teachers must also provide the scaffolding that builds a community of learners that extends beyond inquiry-based discourse. Teachers must link the students’ prior knowledge, previous experiences, and the current lesson in order to maximize student conceptual learning. As students progress from one experience to another they learn, with guidance from the teacher, to reflect on their experiences, to organize their thoughts in line with the purpose of the experience, and to connect them to other learning experiences to create a rich collection of knowledge (Dewey, 1938).

The Piagetian theory describing learning as an interactive process where learners make sense of the world through cognitive themes was one of the foundations of conceptual learning. From this base other and conflicting theories of conceptual learning developed. Contrary to Piaget’s theory of accommodation and assimilation, David Ausubel, 1968, argued that the most influential aspect of conceptual development was the learner’s existing conceptual learning of a particular area (Scott, Asoko, & Leach, 2007). More recently, another theory on conceptual learning emerged based on the works of Vygotsky. From that theory, conceptual development has shifted from meaning-making as a strictly cognitive process toward more of a function within social contexts (Vygotsky, 1978). This shift in the theories of conceptual learning in science summarized the turn from individually oriented theories to the more recent socioconstructivist perspectives of learning.
Vygotsky’s theory on cognition indicates learning involves a passage from social context to individual understanding where the words, gestures, and images within that social exchange provide tools needed for individual thinking to happen on a social plane (Scott, Asoko, & Leach, 2007). In addition to Vygotsky’s social plane theory, his Zone of Proximal Development is a key aspect of an individual’s learning, which is dependent upon the support of those with more expertise. Through communication with others, learners have the ability to develop greater conceptual understanding (Vygotsky, 1978).

Through the 1990s and early 2000s, studies emerged that supported the idea of socioconstructivism, particularly the social origins of learning through interactions of the social plane and in recognizing the social context of the scientific community for the development of scientific knowledge (Scott, Asoko, & Leach, 2007). The theory of socioconstructivism influenced the work of this study. Through the lens of socioconstructivism, these four ideas common to the science concept learning are blended into the sections of this review: (a) learning scientific knowledge involves passage from social to personal planes, (b) the process of learning is consequent upon individual sense making by the learner, (c) learning is mediated by various semiotic resources, the most important of which is language, (d) learning science involves learning the social language of the scientific community, which must be introduced to the learner by a teacher or some other knowledgeable figure (Scott, Asoko, & Leach, 2007, p. 44).

Learning to think and “talk science” is a complex process involving understanding what modes of communication and conceptual constructions are expected and appropriate in various situations (Lemke, 1990; Schoultz, Saljo, & Wyndhamn, 2007, p. 44).
This research study aimed to examine the conceptual learning of fifth grade students as they engaged each other in science based dialogs and independently composed notebook entries originating from guided inquiry-based activities.

Inquiry

Since the creation of the National Science Foundation in 1950 by the United States Congress, inquiry has been a theme of science education. Inquiry may be interpreted and understood in many ways. Based on the National Science Education Standards (NSES) the use of inquiry may be categorized into three main parts: scientific inquiry, inquiry learning, and inquiry teaching (Anderson, 2007). According to the NSES, scientific inquiry is, “the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” (NRC, 1996, p. 23). Inquiry learning is the active process of learning. The NSES link scientific inquiry and inquiry learning in school science through a varied assortment of activities within multiple stages including oral and written discourse (NRC). Inquiry teaching does not follow one specific routine, rather it stems from student-generated interest of a particular topic and blends both scientific inquiry and inquiry learning. The NSES indicate inquiry teaching is, “the activities of students in which they develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world” (NRC, 1996, p. 23). Like the NSES, this study blended scientific inquiry and inquiry learning as students worked in small groups to complete force and motion guided inquiry activities.

Expanding scientific thinking through the use of inquiry instruction is one way to advance student conceptual understanding (NRC, 1996). Students talk, debate, and
challenge each other during inquiry-based classroom activities. As they justify and respond to questions and ideas, they develop connections between themselves and the content they are learning. As students participate in inquiry-based investigations, they construct understanding of science phenomena as they interact with peers to discuss, write, and draw their ideas in their science notebooks (Shepardson & Britsch, 2001).

The NSES (NRC, 1996) advocate inquiry generated from personal experience as key in students’ ability to develop scientific knowledge. Personal experience in the elementary school setting may involve working in small groups of three to five students or working in pairs. Within these arrangements, students are encouraged to share ideas, ask questions, and explain their thoughts. The NSF states that inquiry-oriented instruction stimulates children's natural curiosity and helps them build a deep understanding of science by emphasizing hands-on experiments, research, and discourse (NSF, 2008).

It must be noted, inquiry-based instruction is not about students manipulating tools and having open-ended chats with their classmates. Rather, inquiry-based pedagogy uses a constructivist approach that engages students in the investigative nature of science through explorations of the natural world (Haury, 1993). In the elementary classroom, students explore selected science topics based on mandated state standards. These explorations lead students to ask questions, make discoveries, seek explanations, and test findings as they look for answers and develop new understanding (NRC, 1996).

Science inquiries promote children’s discovery of concepts in ways that make sense to the learner. This knowledge is then socially constructed and expanded during discussions and debates with classmates (Johnson, Dunne, & Mairead, 1996). However,
simple manipulation of tools combined with casual conversation does not make a quality science inquiry. Dewey stressed the need for linking one experience to another to form a completely educative experience. “Continuity and interaction in their active union with each other provide the measure of the educative significance and value of an experience” (Dewey, 1938, p. 45). In today’s classrooms, educators must balance creating educative, inquiry-based experiences for their students while teaching the curriculum mandated by national, state, and local authorities. To successfully implement the process of scientific inquiry in the classroom, the use of a structured instructional framework, such as the 5E model, is beneficial.

The 5E learning cycle model consists of a sequence of five learning phases: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee, 1997). During the engage portion of the inquiry, the goal is to access students’ prior knowledge and pique their curiosity about the science concept or topic. The explore phase provides opportunities for students to use the inquiry processes of observing, questioning, and investigating. The objective is for students to develop basic understandings of the concept introduced during engagement and to develop deep knowledge about materials and ideas related to the concept. Teachers probe students to think more deeply about science concepts and connect the inquiry to real life as they explain key aspects of the inquiry. The extension lesson provides opportunities for students to apply labels, definitions, explanations, and skills in new, but similar situations. Evaluation and assessment can occur at all points along the continuum of the instructional process.

Using the 5E model as an integral part of the classroom science experience is linked to Tyler’s belief that education should be based on the needs of a given population
and lessons catered to meet those needs (Tyler, 1949). Inquiry instruction, through its multiple ways to engage students and freedom to explore scientific concepts is one way to meet the needs of elementary school learners. Simple exposure to an inquiry-based lesson at irregularly scheduled opportunities will probably not enhance student conceptual development. Further, gaining scientific knowledge will not develop immediately, but by striving to incorporate real-world experience, long-term understanding will be built (Tyler, 1949).

Implementing a curriculum with an emphasis on 5E inquiry-based instruction is supported by Bruner’s act of learning (1960). As students proceed through the engage, explore and explain inquiry phases, new knowledge is being created. Discussions during these and the extension phase facilitate the transformation of knowledge to meet the task at hand and extend the understanding to future learning experiences. During the entire process, self-evaluation regarding understanding is confirmed and clarified by discussions with both peers and teachers. If all pieces fit together, a successful learning episode has occurred and learners are able to reflect back on prior knowledge and generalize how to apply information to future works (Bruner, 1960). This study sought to examine the discourse students’ use as they participated in selected learning episodes derived from guided inquiry-based science activities.

Making science content accessible and understandable to all students can be challenging. Lee and Songer (2003) advocate the use of inquiry as one way to help students connect with science while working to solve real world challenges. Using twenty schools, data were collected for four weeks while sixth grade students collected real-time weather forecasts based on the Kids as Global Scientists curriculum. Results of
the study yielded several outcomes. First, when using inquiry-based lessons the real world situations must closely match students’ existing content knowledge while providing ways to develop that understanding to deeper content knowledge. Additionally, during the inquiry experience, students must have guidance throughout the learning process (Lee & Songer, 2003). In this study, the classroom teacher followed a scripted inquiry to provide guidance to the students during the lessons to develop existing knowledge into deep conceptual learning.

**Student Groups**

Ashman & Gillies (1997) conducted a 12-week, mixed methods study on Australian sixth grade students to determine if training the students on how to work effectively in small groups could enhance students’ learning. Several sources were used to gather data from students and teachers including observations, a language rating scale, learning outcomes questionnaire, and perception rating scales for both students and teachers. Observational data were classified into four behavioral categories: cooperation, noncooperation, individual nontask behaviors, and independence. Throughout the observation periods, at five-minute intervals, eight interaction variables were employed to further classify observations. Student remarks that engaged peers were: (a) solicited help or explanation, (b) solicited terminal response (asked yes or no question). Students speaking without prompting from peers was categorized as: (a) unsolicited help/explanation, (b) unsolicited terminal response (yes/no), (c) ignore (d) unsolicited response that could not be classified as explanation or terminal, (e) nonspecific verbal that could not be coded into existing categories, and (f) solicited help that could not be categorized (Ashman & Gillies, 1997). The language scale grouped discourse into three
categories: (a) inclusive—a willingness to listen to others, (b) exclusive-negative/disparaging remarks toward others, (c) group maintenance-language that could not be classified into the previous categories.

Conclusions drawn from the work indicated advising students on how to communicate with each other does improve group cohesion and student learning. Specifically, they found students that had been trained on suitable interactions within small groups were consistently more helpful and cooperative with each other and actively tried to include and support all members of the group in the learning process (Ashman & Gillies, 1997). By taking guidance from this work, this study examined the nature of students discourse as students worked in small groups to complete science lessons and the role gender had on that discourse.

“Everything depends on the quality of the experience which is had” (Dewey, 1938, p. 27). The students’ experience is a central theme to all learning and all experiences are connected. Experience, as explained by Dewey, have a great power to promote or stunt future growth of the learner. All experiences are not good experiences, some may be educative, while others miseducative, but all do affect the learner and the next experience. Dewey stressed that each learner may interpret experiences differently, but the effect of those experiences will affect future experiences in a deeper, more meaningful manner. Working collaboratively within science experiences not only enhances the understanding of science, it also fosters the practice of many of the skills, attitudes, and values that characterize science (NRC, 1996).

“Science is often a collaborative endeavor, and all science depends on the ultimate sharing and debating of ideas. When carefully guided by teachers to ensure full
participation by all, interactions among individuals and groups in the classroom can be vital in deepening the understanding of scientific concepts and the nature of scientific endeavors” (NRC, 1996, p. 32). Creating an environment that fosters peer communication within small groups is essential for inquiry-based instruction. However, it is not as simple as arranging students to sit in a cluster and telling them to discuss the science topic.

Students working in groups must understand the expectations and purpose of the arrangement. In review of the literature, Treagust (2007), listed five methods of instruction that may be used in small group learning: Learning Together and Alone, Jigsaw, Student Teams and Achievement Division, Group Investigations, and Peer Tutoring in Small Investigative Groups.

Learning Together and Alone, based on the work of Johnson and Johnson in 1975 involves groups of four or five students working to achieve a common goal that develops both personal and group skill. Jigsaw, as conceived by Aronson, Stephan, Blaney, and Snapp in 1978, divides a class into groups with each student responsible for a particular task. After completing a task, group members share findings as the expert with their peers. In 1978, Slavin classified group work into Student Teams and Achievement Division which involved class presentation, followed by teacher discussion and worksheets, quizzes or games. Group Investigation, as described by Lazarowitz and Hertz-Lazarowitz in 1998 intertwines investigation, interaction, interpretation, and intrinsic motivation. Similarly, Peer Tutoring in Small Investigative Groups by Lazarowitz and Karsenty in 1990, also involves investigation, interaction, interpretation and intrinsic motivations. For elementary school students, cooperative learning produces
positive results in achievement, helping behaviors, and peer support (Treagust, 2007). In this study, students worked in small groups based loosely on the Group Investigation model.

Shulman, Lotan, and Whitcomb (1998) edited a book detailing group work in various classrooms. Fifteen cases ranging from second grade to high school reported, in narrative form, the experiences for students and teachers engaged in various methods of group work. Despite the notion students need to learn how to access and use various resources to frame and solve problems while working with others group work in classrooms is challenging (Darling-Hammond, 1999). There is not one set way to establish and run small groups in classrooms.

Teachers in science classrooms encourage informal discussions so students are required to explain, justify, argue, and defend their conclusions based on data and critically assess and challenge one another (NRC, 1996). As teachers guide students to collaborate in peer small groups, they must also call students’ attention to individual responsibility within that group. For example, each child should take an active part in the group discussion. Students must practice using semantic tools to improve conceptual learning (Tobin & McRobbie, 1999). During the process students may describe, clarify, elaborate, review, and change their ideas. Within this process, students attempt to resolve if their knowledge fits with peers and if that knowledge can be applied to solving particular scientific problems (Tobin & McRobbie, 1999).

In a report of peer and cooperative learning from 1981-2005, Topping (2005) affirmed students’ academic achievement is aided by peer interactions. By organizing peer learning into thirteen organizational dimensions, he outlined the variety of methods
for peer learning including: curriculum content, group size, group age, ability, role within group, time, place, objectives, voluntary or compulsory, and characteristics of helped and helper. Although peer interactions may include conflicts and challenges, interactions also involve support and scaffolding that are necessary to develop conceptual learning. Within groups, Topping concluded, students of various abilities experienced similar benefits of improving declarative knowledge, procedural skill, and application of knowledge by extending existing abilities.

Small groups are often used in the elementary science classrooms with the purpose of engaging students in productive talk as they generate conceptual learning. However, difficulties based on communication can arise as students work in small groups. Students may lack the ability to effectively communicate their ideas to peers. Students in the groups are neither experts nor teachers, so they may not understand the need to provide clues to understanding to peers instead of providing only a solution (Dawes, 2004). Some students may speak with certainty and convince others in the group of their beliefs, even when the beliefs are incorrect. Based on findings from his study using 154 eighth-grade students, Rivard claimed students may be exposed to erroneous ideas within group discussion (2006). To some children, the complications arising from group work are not worth the rewards. The struggles within groups may disenchant some learners who will direct talk away from science and stop all learning (Galton & Williamson, 1992).

Contrary to the idea of off-topic conversations, in his book about conversations and the social processes of science education, Lemke (1990) proposed the importance of side-talk within small groups. Side-talk can serve three main purposes within group
discussions. First, it can serve as a channel for personal relationships. It can also serve as a medium of clarification between students, such as, “What page are we on?”. Finally, side-talk may serve, as most teachers would suspect, as a way to derail from the lesson. It may serve to provide a way of disengaging from the lesson (Lemke, 1990).

In addition to off-topic conversations, the make-up of small groups has other challenges: bullies and freeloaders. Some students may act as freeloaders and not contribute to the learning. Others may gang up on group members, which may lead to arguments. Depending on group make-up bullies may focus on boys, girls, or students with different ability levels to exclude them from group discussions (Kutnick & Rodgers, 1994). The study examined the nature of students’ oral discourse as they completed science inquiries and how gender affects that discourse.

Rivard (2004) supports small group learning, but notes the collaboration within the groups may benefit some students more than others. Specifically, low achievers may benefit from peer collaboration more than their higher achieving counterparts because the lower level students do not have the same requisite knowledge as their peers (Rivard, 2004). All of these factors are indicators that children have the language to communicate, but have not yet learned how to communicate and listen to peers effectively and the learning may be impeded.

Meyer and Woodruff (1996) proposed three dependent mechanisms for the increase of students’ conceptual learning within small groups: mutual knowledge, convergence, and coherency. Mutual knowledge is the first part of group work where students try to find common ground during predictions and initial explanations of phenomena. In Meyers and Woodruff’s study, students regularly used analogies to
clarify their point of view to peers. Convergence followed which involved students trying to add to established common knowledge. By asking “What if” questions to peers, students try to establish what matters in the investigation and converge on relevant variables to produce group statements of beliefs. Finally, coherency is the agreement within a group that converged upon an idea that “fits” the larger scientific phenomena. Elementary students have not yet mastered communication styles and discourse that allow students to effectively express themselves and can be challenging to some students. The work of Meyer and Woodruff illustrates the significant link between student groups and discourse. The natures of student discourse, both oral in small inquiry groups and independently composed in science notebooks, were investigated in this study.

**Gender in the Elementary Classroom**

Research into gender and the classroom has been conducted over the past forty years (Anderson, 2007). Using that time span as a guide, a search of the literature was conducted focusing on the terms gender and elementary science. The following frequency chart shows findings from three major databases: Web of Science, EBSCO Host, and Education Full Text regarding the number of articles focused exclusively on gender and elementary science.

During the 1970s there was little interest in the intersection of elementary science and gender. The 1980s showed a slight increase of interest. The 1990s brought the official recognition that gender was an important issue in science education (Scantlebury & Baker, 2007). Studies on gender in the elementary school classroom cover a range of topics including, but not limited to, attitude, motivation, participation, same and mixed
Table 1

Frequency of Literature on Gender and Elementary Science

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<td>2002–2008</td>
<td>36</td>
<td>92</td>
<td>52</td>
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groups and classes, and cognition. This study focused on oral and independently composed written discourse of elementary students within small science groups.

The earliest study on gender, 1969, was conducted on cognitive styles and student achievement of boys and girls in the United Kingdom and Australia. Findings suggested differences in processing of information between boys and girls. Due to slower formal operations development by girls, boys earned higher science achievement scores (Field & Cropley, 1969). However, over the past four decades research studies have been conducted and contradict the early work of Field and Cropley. In 1978 Kelly conducted a review of literature and proposed societal factors, rather than cognitive differences, that may affect higher achievement of boys than girls in science education (Scantlebury & Baker, 2007).

Patchen and Cox-Peterson (2008) have classified science into a two-tiered system: (a) science education that resonates with White, middle-class students (presenting themes, methods, locales, and scientists that resemble their lives), (b) science education that is often unrecognizable or incomprehensible for students from different
ethnic, linguistic, or class backgrounds. The interrelation of gender, race, ethnicity, culture, and social class makes it difficult to separate data based on specific variables that influence science learning (Luykx & Lee 2007).

Kurth and Smith (1997) conducted a qualitative study on first and second grade students and the influence of gender and culture on students’ science discussions. The study took place over a one-year period and used whole group field notes, observations, and small group student interviews representing various genders and participation patterns. Data showed gender clustering in students’ seat selection, turn taking, and contributions that led to the alignment and building of scientific concepts by successive same gender speakers.

Concurring with recent literature, Thorne suggested gender is socially constructed (1993). From infancy boys are dressed in blue and given trucks and blocks while girls are dressed in pink and given dolls and dress-up clothes. Gender stereotypes found in media, television, and movies further delineate what is male and female. By the time students enter school the ideas of how boys and girls should act are well ingrained. In her ethnographic account, Thorne described group life which is the organization and meaning of social situations and the collective practice through which children create gender roles in daily interactions (1993). This study investigated the gender roles of fifth grade students as they participated in small group science inquiries and then responded independently in science notebooks.

Gender stereotypes and their effect on students’ self-perceptions of science abilities were further examined by Kurtz-Costes, Rowley, Harris-Britt, & Woods (2008). Using the frames of social status theory and cultural/experimental theory, children's
awareness of adults' stereotypes and children's own perceptions of group (i.e., boys’ or girls’) competence, as one avenue by which stereotypes may influence children's developing self-concept and thus lead to gender differences was studied. Results of the study were consistent with cultural-experiential theory in that stereotypes were more consistently related to self-concepts among boys in middle school than among elementary school boys. The self-concepts of boys appeared to be enhanced by their perceptions of adult stereotypes favoring the science abilities of boys over girls. However, these stereotypes were unrelated to self-concepts among girls, yet were not coupled with positive science self-concepts.

In a similar study, Britner and Pajares (2006) examined students’ self-efficacy beliefs toward science achievement. Bandura (1986) contended that students’ self-efficacy beliefs are predictors of academic success by influencing a number of behavioral and psychological processes. In science, Britner and Pajares indicated students who have a strong belief that they can succeed in science activities were more likely to select such activities, work hard to complete them successfully, persevere in the face of difficulty, and be guided by physiological indexes that promote confidence as they meet obstacles. Findings indicated minimal gender differences. Boys reported more mastery of science skills and higher science self-concepts. Girls reported greater science anxiety, but both boys and girls had equal science self-efficacy. Social persuasion that involves feedback, both verbal and nonverbal from peers, was noted to be an important piece of information. Students who were told by peers that they have the ability to master new or difficult science tasks were more likely to persevere in the face of challenges and mobilize the effort needed for efficacy-building (Britner & Pajares,
2006). This study examined the discourse of elementary students and the role of gender on that discourse.

A meta-analysis conducted in 2006 further identified differences between boys and girls (Else-Quest, Hyde, Goldsmith, & Van Hulle, as cited in Larson & Bruss, 2007). Data suggests girls show more inhibitory control, the ability to refrain from unacceptable and inappropriate actions, than boys between the ages of 3-13. Consequently, it could be suggested girls are better behaved in school and spend more time developing conceptual learning. Along behavior lines, the same meta-analysis by Else-Quest et al. suggests boys have a higher level of surgency, degree of activity and impulsivity, than girls during these ages (Larson & Bruss, 2007). Children’s temperaments affect their interactions with peers. Girls work together to build relationships and share ideas. Boys are overtly competitive and hierarchal: ranking themselves through insults, direct commands, and challenges (Thorne, 1993). These contrasting interpersonal skills may affect elementary students’ conceptual learning as they work in small groups. This study examined the nature of fifth grade students’ discourse as they were arranged in small groups to complete science inquiry-based activities.

**Gender in Small Groups**

Confidence and interactions with the teacher and peers may affect students’ science learning during inquiry-based lessons. Boys have more confidence in their abilities to do science whereas girls see themselves as science outsiders, which is described as one with little self-confidence in science abilities (Shakeshaft, 1995). Self-perception of one’s abilities may influence students interactions with peers and those interactions may vary depending on gender make up of student groups. In 1996, Rennie,
Parker, and Kahle noted when students were grouped in same gender groups, teachers regularly initiated teacher-student interactions with boys while girls in the all girl group initiated teacher interactions. The outreach for teacher attention may support the theory that girls have less science confidence needed to complete activities independently.

Confidence may also influence students’ interactions with peers while working in small groups. Boys selfishly try to assert control over materials while girls focus on relationship building within small groups (Jones, Brader-Araje, Carboni, Carter, Rue, Banilowere, & Hatch, 2000). Consequently, Jones et al., suggest girls’ performance in inquiry-based science lessons may exceed boys because of their ability to focus on the task at hand rather than competition with peers. Contrarily, Mewborn (1999) suggests girls do not have science confidence because of the frequency, while working in small groups, girls volunteer for secretarial tasks rather than hands-on active participation, which limits conceptual learning. Conceptual learning may be further impeded if girls do not even have the confidence to act as the group scribe. Girls willing to sit and simply observe the inquiry while others discuss and interact can lead to a monopolization of discourse by only a few students. The role of gender in small groups was examined in this study as students’ completed force and motion inquiries.

“Power is central to the social relations of gender” (Thorne, 1993, p. 159). In classrooms, boys tend to dominate space with their presence and actions. Being the first to grab the supplies or calling out to get the teacher’s or a peer’s attention are commonplace. Teachers are more tolerant of call-outs from boys than girls who are reminded to wait their turn and be polite (Shakeshaft, 1995). Perhaps because of their boisterous nature, boys prefer working independently in small groups with little input
from the teacher which is in contrast to girls who prefer working with teacher guidance (Jarvis & Pell, 2002).

In addition to confidence and power, the role of friendship is another aspect of working in small groups that may affect conceptual learning. Based on the Vygotskian socioconstructivist theory that states collaboration leads to cognitive growth when participants arrive at a shared understanding of a particular topic, grouping of students should be paramount. Swenson and Strough (2008) categorize the successes and challenges of friends working cooperatively. Using 132 high school students, Swenson and Strough paired students with a same gender friend or nonfriend to discuss two scientific reasoning questions. When grouped with friends, boys performed significantly worse on scientific reasoning tasks, than when grouped with nonfriends; classmates with whom they were not particularly close. Conversely, girls performed better when grouped with friends. Perhaps the ability of friends to challenge and support one another in scientific tasks can assist in the development of conceptual learning for some students. In this study, the nature of boys’ and girls’ discourse while working in small groups was detailed.

**Gender and Student Discourse**

Documenting the links between gender and discourse can be challenging, but several studies have explored the concept. The work of Kurth, Kidd, Gardner, & Smith (2002) focused on discourse during elementary science class. Findings suggest differences based on gender roles. Boys received more chances to talk than did girls. Within those talk opportunities boys expressed more language features in both narrative and paradigmatic discourse patterns. It is acknowledged that there is variation in
students’ comfort levels and willingness to talk, however, the collaboration with peers is needed to improve scientific understanding (NRC, 1996).

Comfort level with peers may be one reason students prefer single gender groups. Another possibility is the speaking patterns of boys and girls differ, so students prefer being grouped homogeneously. The American Association of University Women (AAUW) (1992) issued a call for reports and research on the experiences of American girls in school from Kindergarten to high school. From the 1,300 studies that were selected and analyzed, the AAUW report explained the speaking patterns of students that the work of Thorne supports (1993). Thorne spent eight months in one public elementary school in California during the 1976-1977 school year as an ethnographer focused on fourth and fifth grade students in the classroom, cafeteria, and playground. During this time, Thorne drew the conclusions girls frequently used indirect speaking patterns involving questions whereas boys favored direct speaking patterns involving declarative sentences.

In an effort to broaden the international availability of research on gender and discourse, Aukrust (2008) conducted a study of gender in 26 Norwegian primary and secondary schools. Findings indicated four main characteristics of discourse were found: frequency of participation, turn allocations, spontaneous utterances out of turn (comments), and overlapping utterances. Frequency of participation included a broad classification of how often each gender spoke. Turn allocations were related to how frequently the teacher selected a student to speak. Spontaneous utterances referred to the side comments made between group members that were not part of the main discussion. Overlapping utterance was the frequency two or more students were talking
simultaneously. Overall, boys had a greater discourse participation rate than girls, however, when girls were given the floor to speak by the teacher, their participation surpassed boys. Regarding spontaneous utterances boys took the floor themselves nearly three times as frequently as girls. Boys had more simultaneous talk with the teacher and sideline comments than did girls (Aukrust, 2008). Discourse with peers and teacher is one way to expand students’ conceptual learning. Understanding the role gender has within that discourse is critical to creating classroom groupings that facilitate and enhance student discourse. Cazden asserts, “opportunities to become fluent and confident in speaking in public may be the most important aspect of gender equity in classrooms” (Cazden, 2001, p. 86). This study aimed to contribute to the field of science conceptual learning by documenting discourse, oral and written, as students participated in small group inquiries.

**Discourse**

“Understanding of how language works … is essential for enabling teachers to effectively support all students’ growth in academic language—the language used in schools to learn, speak, and write about academic subjects” (Darling-Hammond & Bransford, 2005, p. 127). Teachers in elementary classrooms can act as role models for students to observe and mimic appropriate science discourse. In elementary classrooms, small groups in science class allow students to share ideas and publicize their understandings of terms so peers can work toward a common understanding (Kutnick & Rogers, 1994). Teachers can support students’ advancing conceptual learning by guiding students to use effective communication styles while working with peers.
For some students, the use of analogies and metaphors are effective tools to aid them in clear communication of scientific phenomena and conceptual learning with peers. The use of analogies has been linked with expert-like thinking in the elementary classroom (May, Hammer, & Roy, 2006; Meyer & Woodruff, 1996). Students that express their conceptual understanding through the use of analogies link the known with the unknown of scientific phenomena. By doing so they express their thinking within the content area with the thinking of peers. Discussions, validation, and inferences allow students to refine and enhance their thinking. Likewise, Jakobson and Wickman (2007) profess children’s use of metaphors have the potential to enliven and humanize the subject of science. Based on Dewey’s ideas of the continuity and transformation of experience they concluded children’s use of metaphors involve cognitive, normative, and aesthetic conceptual transformation. However, teachers must be prepared to listen beyond the superficial level of what students are saying to deeper, less obvious, how they are saying it in order to facilitate conceptual learning (May, Hammer, & Roy, 2006).

Lemke acknowledges the difficulties some students have with communication and further challenges educators to see science as its own discourse. The learning of science is comparable to the learning of a new language with particular ideological, semantic, and syntactic implications (Lemke, 1990). Understanding the intricacies involved with students working in small groups is challenging, and this study examined discourse as fifth grade students’ worked in small groups to complete inquiry-based science activities.
Science Discourse

*The Handbook of Research on Science Education* dedicates a chapter to discourse in the science classroom reviewing empirical studies focused on the form, function, or interactional functions of language use. During the review Kelly (2007) argues for the importance of viewing education through the lens of language and social processes. Kelly begins the review with studies of spoken discourse in classrooms. Spoken discourse is further broken-down into discourse studies of classroom teaching and knowledge, discourse, and conceptual change, student small group discourse, studies of argumentation, explanation and students use of evidence, and equity. The next major classification for studies in the review is focused on written discourse classified under learning and teaching writing and reading in science. Subcategories include reading and science learning, learning to write science, and writing to learn science. Throughout the review, Kelly notes analysis of discourse in science education is dependent on researchers’ theoretical position as well as choice of research approach. Consequently, there is great variety on how discourse studies are conducted. Throughout the review two key issues emerged: the structuring of knowledge through discourse and the potential equity concerns found in the construction of science knowledge through discourse (Kelly, 2007). This research study focused on the construction of scientific knowledge during discourse as students worked both in small groups and independently.

The varied aspects of students’ discourse in the classroom are illustrated in recent studies. Based on the idea science learning is a social activity, and during that activity the teacher holds the most power, several studies have addressed discourse patterns that evolve in classrooms. Lemke (1990) termed the phrase triadic dialog to describe the
patterns initiated by the teacher and followed by the students. Triadic dialog follows the pattern: teacher question, student answer, teacher evaluate. Similarly, Mehan (1979) labeled the same talk pattern as IRE-Initiation-Response-Evaluation. The focus in both discourse patterns is on the teacher. The teacher’s pedagogical, content, and classroom climate preferences all affect the patterns used in the classroom. However, as Lemke points out, when the discourse is teacher-centered, students are left with little room to ‘talk science’ which limits conceptual learning.

Talk prepares students for generating new understanding, but the work of Dawes (2004) points out several challenges with student discourse compiled during the Nuffield Thinking Together project. The mixed methods study used both experimental and control classes of fifth grade students in England. One group was trained in useful strategies to negotiate and communicate scientific ideas through dialog and one was not. First, newly formed understanding and uncertain construction of learning provides a weak foundation for student conversation. Next, peers may be unsupportive of each other and insecurities can prevent some students from speaking. Contrarily, others will speak, but not about science concepts. Regardless of the challenges students must be able to articulate ideas to consolidate learning and develop conceptual learning.

van Zee and Minstrell (1997) examined students’ development of science concepts by focusing on a student-centered, rather than teacher-centered talk pattern. They conducted a case study concentrating on student and teacher questioning and focused the discourse analysis on a pattern of talk described as a reflective toss. A reflective toss is directed by the teacher, but focused on students’ ideas. A reflective toss is built upon the following structure: student statement, teacher questions, and student
elaboration. Reflective tosses are used regularly in the study as classroom teachers try to promote and deepen students’ conceptual development of science topics through whole group question posing.

Gallas’ (1995) study concurred with van Zee and Minstrell on the importance of acknowledging students’ ideas and questions in the classroom. In her work, Gallas focused on students’ questions as a teaching strategy that broke the focus from the teacher and refocused on students. This emphasis is contrary to the teacher-centered work of Lemke and Cazden, but in line with Crawford, Kelly, and Brown (2000) who also conducted work on students as creators of questions that teachers then used to guide curriculum focus.

Lapadat (2000) investigated how students construct meaning and how that meaning can be altered through discourse. Lapadat’s case study included two Canadian elementary students, one boy in grade seven and one girl in grade six. The study took place for one hour, once a week for a six-week unit on space. During that time sessions were audio and video taped, students kept a journal, and the researcher described and reflected on each session. Through analysis of researcher notes, transcripts, and copies of students’ journals, themes of students’ changing conceptions of scientific phenomena, space, were coded and categorized. Findings suggested students’ conceptual change is related to the focus of the discourse. Kovalainen and Kumpulainen (2005) examined student discourse through a socioconstructivist lens and classified discourse patterns of elementary students into ten categories: evidence negotiation, defining, experiential, view sharing, information exchange, orchestration of classroom interaction, nonverbal communication, neutral interaction, confirming, and evaluation. Of these asking for
evidence, views, information, and definitions occurred most frequently. This study aimed to detail the nature of discourse of fifth grade students using several of those categories: view sharing, information exchange, explanation, and confirming discourse were noted as students discussed, debated, and questioned each other during inquiry-based activities (Kovalainen & Kumpulainen, 2005).

**Writing for Conceptual Understanding**

The use of writing as a tool for assessment of students’ conceptual learning is commonplace. Writing can be used as formative or summative assessments that serve as indicators of students’ progress. However, for elementary school children, the shift from oral to graphic representation of learning can be challenging. This study examined written discourse for evidence of conceptual learning as students composed independent entries in science notebooks following the completion of science inquiries conducted in small groups.

**Writing in Science**

Over the past twenty years, national efforts to reform science education have advocated a shift from memorization of science facts toward deep conceptual understanding (NRC, 1996). This study examined evidence between students’ science conceptual learning in small group discourse and their independently written reflections of science topics in science notebooks. Currently there are few, but increasing, numbers of studies that focus on the integration of spoken and written discourse. In this review, studies that consider the two discourses were the focus.

Writing in science is another dimension of discourse studies conducted within the field of science education. In a meta-analysis, Prain and Hand highlight three main
theories on written discourse: modernist, constructivist, and postmodern (1996). The modernist theory supports the use of technical scientific language in student work. The constructivist theory supports writing as a tool to build scientific understanding. The postmodern theory focuses on the socioconstructivist aspects of written scientific concepts (Prain & Hand, 1996). In this study, the constructivist perspective describes the expectations of student writing.

As students reflect on inquiries and interactions with peers and then write in their science notebooks, they are able to make sense of the inquiry. By focusing their thoughts on the investigations and organizing that knowledge in a way that is supported by scientific evidence students deepen their conceptual understanding. By creating personal journal entries children construct or reconstruct science phenomena through their lens of understanding (Shepardson & Britsch, 2001).

Understanding of science concepts is developed through the active construction of knowledge as students explain science concepts to themselves and others in their science notebooks (Chi, 2000). Chi further explains the dual purposes of science notebooks. First, notebooks reflect multiple parts of a classroom including a single student, a sample of students, or the whole class. As students’ conduct guided inquiry-based activities, they record their thoughts and discoveries in science notebooks. Entries may be teacher directed in the form of a Quick Write, a free-form reflection, or more specific records of observations and data, but both serve as indicators of students’ conceptual learning. Notebooks are immediate sources of data teachers may seek out as formative assessment tools. Second, notebooks may be used as a direct reflection of the students’ understanding of the implemented curriculum.
Science notebooks provide a window for examining how students connect their personal experiences with science experiences (Shepardson & Britsch, 2001). Notebooks reflect real-time learning which reveals students’ thinking. Teachers can use the students’ notebooks as a formative assessment tool and to monitor students’ understanding of specific concepts and modify instruction if needed (Aschbacher & Alonzo, 2006). The science notebook provides multiple opportunities for students to receive feedback on their thinking and learning during the formative assessments. Students may share knowledge with peers and teacher by writing representations of conceptual learning in a science notebook. This study examined students’ written discourse in science notebooks for evidence of conceptual learning and the role of gender on that discourse.

Student writing is not limited to one type, rather it may fall any number of places within a continuum from points of utterances and spontaneously written explanations to rhetorical and epistemological perspectives (Rivard, 2004, p. 423). Using a quasiexperimental comparison group design, Rivard studied 154 eighth grade participants from four Canadian schools who were assigned one of four treatments: talk only, writing only, talk and writing, and comparison (2004). During a unit on ecology, participants completed five problem-solving sessions in their assigned group while being videotaped. Four-point rubrics ranging from incorrect to excellent were used to analyze ideas shared by peers and to see how, if at all, the discussions enhanced written responses. Participants also completed a pre/post multiple-choice test. In the study, the range of student writing included teacher directed Quick-Writes and free-form reflections after students completed inquiries in small groups to discover patterns, if any,
between the nature of students oral and written discourse. Studies have suggested writing for science learning has potential to increase students’ conceptual learning, but work has not pinpointed specific techniques (Aschbacher & Alonzo, 2006; Klein, 2000). However, it has been suggested, “writing is to be used as a learning tool, it would be more useful to deploy it in combination and as integrated with other forms of learning and discourse, such as reading, classroom discourse, and group discussion” (Tynjala, Mason, & Lonka, 2001, p. 14). Rivard supports the notion that talking and writing are complimentary. Construction and retention of science conceptual learning is enhanced with the combination of graphic representation of ideas and verbal exchanges (Rivard, 2004).

A key purpose of writing in elementary science is to show conceptual understanding (Mason, 1998). However, expressing that understanding may be difficult for elementary students. The form of expected graphic representation may keep some students from actively engaging in the experience. When students were asked to copy notes from the board or to copy large amounts of teacher prescribed prompts, students were bored (Appleton, 2007). However, when used properly, science notebooks can be used to record students’ thinking and ideas. Shepardson and Britsch (2001) advocate the use of student-centered notebooks as evidence of content knowledge. For elementary students, they suggest notebooks categorize students’ ideas into three mental contexts: imagination, previous experience, and science investigations to show student conceptual learning.

Mirroring the importance of the type of writing, Mason (1998) highlighted the traditional science writing as a tool for teachers to check students’ learning of the information transmitted to them. More recently, writing has been seen as a powerful tool
to connect new knowledge, explain and clarify thoughts, reflect on conceptions, and synthesize new ideas. Based on the newer ideas of Rivard (2006) science writing may be classified into two categories, expository, and expressive. The first includes note taking, summarizing, analyzing, and explaining. Expressive writing refers to a blend of a science notebook and personal journal. Of the two, reflective writing has received less research and fewer positive findings than expository writing (Mason, 1998; Rivard, 2006).

Despite the imperfections with writing in science, it is still a worthwhile tool for students to showcase their learning. This study focused on a combination of expository and expressive composition of notebook entries in the form of data collection and Quick-Writes after the fifth grade students completed science inquiries.

**Conclusion**

This review focused on five main contexts: science conceptual learning, discourse, writing for conceptual understanding, role of teacher in small group learning, and gender in the elementary classroom. Description of methodologies follows in chapter 3. Chapter 4 details results of the study and chapter 5 details conclusions of the study.
III. METHOD

This study used a sociocultural perspective to investigate the written and oral discourse as it related to the conceptual learning of grade five students within one science unit. Relationships that existed between the written and oral discourse with respect to students’ science conceptual learning were examined. Within the frame of conceptual learning, discourse similarities and differences by gender were studied. The design of the study was flexible in order to attend to information that emerged during the course of the study and analysis of data.

Methodology

The study used qualitative methodologies to describe the interactions of fifth grade students from one suburban public elementary school in southeast Florida. Denzin & Lincoln (2005) describe qualitative research as a situated activity that locates the observer in the world of the participants and attempts to make sense of the phenomena based on the participants’ meaning. Meyer and Woodruff (1996) concur that studying knowledge building in the classroom is optimal to capture the essence involved with collaborative learning and sociocognitive processes. In this study, the researcher examined the written and oral discourse of fifth grade students in their world of an elementary school classroom for the purpose of determining the nature of students’ oral and written discourse as well as patterns between students' evidence of conceptual learning in small group discourse and their independently written evidence of conceptual
learning. The study focused on emerging themes based on data collected in a natural setting, the elementary classroom. Themes were based on inductive data analysis shaped by the collection and analysis of data during the study. However, the behavioral classifications of Ashman and Gillies (1997) and the types of discourse that might impact conceptual learning as suggested by Tobin and McRobbie (1999) were used as guideposts during the analysis. Methodological triangulation (Denzin & Lincoln, 2005) was used in the study with participant observations, interviews, document analysis of student science notebooks, field notes, and reflective memos. For this study, the oral and written discourse and the associated conceptual learning were based on participants’ interactions with others.

**Research Methods and Design**

A case study approach was selected for this study because of the boundaries that are inherent with conducting research at a public elementary school. Being placed in the class prior to the school year beginning predetermined the participants. Asmussen and Creswell determine a case study may be employed when there is a bounded, or closed, system in place. Within that closed system a detailed picture of the experience is created (1995). Erickson (1986) advocates that case studies provide depth, insight, and perspectives that are useful in various contexts. More specifically, researchers in science education have found case studies helpful in understanding the complexities of science classroom practice (Appleton & Asoko, 1996). The case study approach allowed the investigation to retain the holistic and meaningful characteristics of real-life events (Yin, 1994). In this study, qualitative research was used to develop a complex understanding of student discourse in fifth grade classrooms as specifically related to evidence of
conceptual learning in small group discourse and their independent written evidence of conceptual learning. Further analysis of similarities and differences between genders were analyzed.

**Research Questions**

The research questions for this study were:

1. What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities?

2. What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning?

3. What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning?

4. How does gender influence discourse during independent writing and group communication as related to conceptual learning of the science material?

**Participant Selection**

Student participants in this study were members of the fifth grade class at one public, K-5 elementary school in southeast Florida. The entire grade consisted of five fifth-grade classrooms with a total student population of 122. The researcher was a fifth grade teacher at the site; however, her class was not used in the study. This class and a class of gifted students were purposefully excluded from the study. The three remaining classes were used. For this study, classrooms were referred to by teachers’ names, which were pseudonyms. Student participants were also referred to by pseudonyms, but gender
of the student was evident by pseudonym. During the study, there were 76 participants, 39 boys and 37 girls in each of the three participating classes. From that population, one group of four-six students per class was randomly selected as the targeted group. That group was observed, voice recorded, and interviewed throughout the study. A total of 15 students participated in the study, seven boys and eight girls.

Human Subjects Research Approval was sought from the Institutional Review Board of Florida Atlantic University (Appendix A). The Institutional Review Board of Broward County (Appendix B) was contacted following University approval. Permission from Principal (Appendix C), consent from parents (Appendix D), and assent from students (Appendix E) were obtained, with no penalties for not participating in the research.

Teachers in the study have been teaching for a range of years and have varying opinions and levels of enthusiasm for the subject of science. All teachers were volunteers. Teachers were assigned their current grade level by the school principal based on teaching history and résumé. All teachers consented to participate in the study (Appendix F) and agreed to complete a demographic information sheet to provide background information.

Two teachers were male and one was female. All teachers were given pseudonyms. The first male teacher, Mr. Green, has been teaching for eighteen years. He holds a Master’s degree in elementary education as well as a National Board for Professional Teaching Standards Certification. The second male teacher, Mr. West, has been teaching for thirty years and holds a Bachelor’s degree in elementary education. He too holds a National Board for Professional Teaching Standards Certification. The final
teacher, Dr. Johnson, has been teaching for ten years and holds a Doctor of Education in Curriculum and Instruction.

The classroom teachers that participated in the study were accustomed to planning together and sharing inquiry-based and traditional lessons. The classroom teacher was not the focus of this study, so a scripted inquiry lesson plan, which is the typical format used by the teachers, was provided to all teachers for each lesson (Appendixes G-L). This lesson format was used throughout the year and was not new to either teachers or students. Each lesson outlined a sequence of key questions for the teacher to ask the students, whole group, to guide their learning, move the lesson forward, and assist in conceptual development. Following the teacher posed questions, small groups generated discussions, questions, and ideas on force and motion.

**Site Selection**

Dolphin Elementary, a pseudonym, opened its doors as a brand new school on August 24, 2009. Dolphin was built as a Kindergarten to fifth grade school to alleviate overcrowding of two neighborhood schools. Of the three schools in the town, Dolphin was the smallest with a school population of 710 students. Of those students, 523 were white, 36 were black, 80 were Hispanic, 1 was American Indian, and 16 were multiracial. Dolphin Elementary had 5.56% of its students participating in free or reduced lunch programs. The faculty and staff at Dolphin Elementary consisted of 47 members, of which 35 were classroom teachers divided into grade-level teams.

**Procedures**

Taking guidance from Bybee’s 5E inquiry, six inquiry-based lessons were shared with the participating classroom teachers during weekly team meetings. All fifth grade
teachers have used the 5E format of lesson plans since the beginning of the school year. The style was not new to the teachers or students, although each teacher deviated slightly from the lesson to meet the needs of the class. Each lesson followed the same format, Engage, Explore, Explain, Elaborate, and Expand which the teachers directed whole group using guiding questions and students implemented in small groups.

Three fifth grade teachers volunteered their classrooms to be part of this study. Teachers allowed the researcher into their science class for observational purposes during six science lessons on force and motion. The researcher observed six inquiries for each class. During every lesson, each teacher agreed to try to avoid deviating from the script of each lesson to provide lessons as similar to their colleagues as possible.

The six inquiry-based lessons selected for this study represented one unit of state mandated science standards, force and motion. Orange County Public Schools, in fulfillment of the Sunshine State Standards, developed all lessons. Task analyses for each lesson were written for each Sunshine State Standard benchmark, or group of benchmarks, to define and explain them in terms of what should take place in the classroom (OCPS, 2009).

The inquiries took place in the fifth grade science lab at Dolphin Elementary. The researcher set up all necessary teacher demonstration tools, student manipulatives, and general supplies prior to each lesson. The science lab was furnished with seven large rectangular tables that accommodated groups of four to eight students. Average class size was 26 students, so teachers arranged their students into groups of four to six students, as recommended by Cohen (1994). Allowing the classroom teacher to arrange the student groupings promoted the least disruption in the students’ daily experience.
Other than size of student groupings, the researcher did not put any constraints or restrictions on the groupings of students.

Data were collected from the six inquiries within the force and motion unit. The force and motion unit was selected because of the necessity of the students to work in small groups to complete each assigned lesson. Data were collected from three classes over a four-week period. Each classroom teacher selected a one-hour time slot within the normal school day to complete the lesson. To ensure the cooperation of the classroom teachers, each was given the choice to select the hour and date that worked best in his/her schedule.

At the beginning of each of the six inquiries, the classroom teacher read the student notebook script (Appendix M). The script provided instruction and reminders for the students on the use of the science notebooks. All students participating in the inquiry used their science notebooks throughout the activity to note hypotheses, collect data, make claims, and draw conclusions based on evidence. Following the completion of the inquiry, students were reminded of the Quick Write portion of the script. The Quick Write served as a free-form reflection of the experience as well as a place for students to explain what they learned during the activity. Students were given five minutes to complete the Quick Write.

Prior to the first inquiry one student group from each of the three classes was randomly selected as the targeted group for all subsequent inquiries. In the science lab tables were numbered one through seven. All table numbers were entered in a bag and one was randomly selected. Students sitting at that table were targeted as participants for observations, interviews, and document analysis of their science notebooks for each of
the six inquiries. That randomly selected group had a voice recorder placed at the table to record all group discourse. Focusing on one group per class allowed for a multi-layered collection and analysis of data regarding student discourse and conceptual learning in science class. A total of three groups were observed, one group per class, per science inquiry. Choosing one group per class for intensive analysis increased the data with regard to discourse and interviews, but decreased the scope of data for the written analysis of students’ discourse in science notebooks.

A voice recorder recorded all discourse of the randomly selected group during each science inquiry. Recordings were transcribed verbatim. Unclear mumblings and remarks were omitted from transcripts to make discourse more apparent. For clarity of transcriptions, students said their names at the beginning of the inquiry to aid in accurate transcriptions regarding which student participants made a particular statement.

After the second and last inquiry all targeted groups were interviewed. The student participants were asked to respond to a ten-question, scripted interview. Participation in the interview process was optional, with no penalty for nonparticipation. All students volunteered to participate. A total of 29 interviews were conducted.

**Data Collection**

Data collection for this qualitative study took place in the spring of the 2009-2010 school year. Data for this case study was bound by the collection of data from three fifth-grade classrooms in one public elementary school. There were four main data sources for collecting data: small group observations, small group transcripts, participant interviews, and science notebook documents. Researcher field notes and reflective memos completed the data collection. Small group observations were used to gather data
on research questions one, three, and four to study the nature of students’ oral discourse and the role of gender within those groups as students developed conceptual learning of force and motion. Small group transcripts were used to address research questions one, three, and four. Student participants’ interviews were used to address research questions one, three, and four focused on the nature of students’ conceptual learning as they participated in small group science inquiries. Science notebook documents were used to address research questions two, three, and four.

Instrumentation

This study used a sociocultural perspective to investigate the written and oral discourse as it related to the conceptual learning of grade five students within one science unit. Relationships that existed between the written and oral discourse with respect to students’ science conceptual learning were examined. Within the frame of conceptual learning, discourse similarities and differences by gender were studied.

Instruments in this qualitative study were selected and constructed based on the degree to which each instrument would assist in gathering data to answer each research question.

Instruments included observation protocols, voice recordings, participant interview protocol, participant science notebook document analysis, and field notes. Alignment of research questions and instruments are outlined in Appendix N.

Inquiries

Orange County Public Schools (OCPS) as part of the science curriculum available to all teachers in the district, provided the lessons used in the study (OCPS, 2009). All lessons followed Bybee’s 5E framework, Engage, Explore, Explain, Elaborate, and Evaluate (1997). Every lesson was aligned with state science standards.
Although the stages of 5E inquiry are listed as five separate steps, 5E inquiry is not a formulaic teaching strategy. Frequently two steps occur simultaneously. For this study, the classroom teacher used the scripted lesson to ask probing questions to the students as a whole class. Based on students’ responses, the teacher clarified or corrected information students had about scientific concepts with the entire class. The discourse with students during the explain phase also allowed the teacher to evaluate students’ conceptual learning. For this study, student-teacher interaction was scripted. In some cases, teachers needed to slightly deviate from the script to meet the needs of the class. When this occurred, it was noted in observational notes. Throughout each lesson, the classroom teacher posed general guiding questions about the activity to the whole class and students’ responded to those questions within the small groups. The discourse occurring within the groups, before, during, and after teacher posed questions or comments was recorded and transcribed.

Inquiry one, Penny Push, began the unit on force and motion by introducing the topic of energy. As students worked in small groups, they explored the transfer of energy from one object to another.

The teacher engaged the students in the lesson by lining up a row of Dominos on the LCD projector and asked: What will happen when one Domino at the end of the line is pushed forward? After students shared responses, the teacher posed the focus question of the inquiry. As students worked in small groups they were asked to reflect on the focus question: How is energy transferred from one object to another?

With the small group, students arranged nine pennies in a row. A tenth penny was placed approximately 12 centimeters from the row as the knocker coin. Students
gently pushed the knocker (tenth penny) into the row and observed. Students rearranged and retested the penny rows several times. First, they increased the force of the push. Then they pushed the knocker more gently. The number of pennies was reduced to eight and two pennies were used as knockers to push into the row. Finally, the students freely explored using different amounts of coins as the knocking coins and different numbers of pennies in the row.

As students worked, the teacher circulated and explained to the class a force is any push or pull that causes an object to change its state of motion. The teacher asked thought provoking questions to the class that the students responded to in their small groups such as: What happened when the force of the pushed coins was increased? What happened when the size of the pushing coin was changed? When did an energy transfer occur? Introducing a variety of coins with different sizes, shapes, and masses extended the inquiry. Using conceptual learning from the first inquiry, students generated and conducted additional inquiries using the new supplies.

Inquiry two, Motion Notion, was designed around the concept of inertia. Intertwined with the concept of inertia were kinetic and potential energy. As students worked in groups arranged by the classroom teacher, they were asked to think about the focus question: What is inertia and how does inertia affect the movement of objects?

The inquiry began with the teacher engaging the students using marbles and their motion to introduce the First Law of Motion. The teacher placed an embroidery hoop and four marbles under an LCD projector and asked why they were not moving. The teacher then asked the students for suggestions on how to make the marbles move. After trying several of the students’ suggestions, the teacher divided the class into groups and
assigned their group task. Within the allotted time, each group had to create a maze inside the top of a shoebox lid using thin strips of corrugated cardboard. Once the strips were glued in place, the students explored the First Law of Motion by placing a marble at one end of the maze and, without tilting or lifting the box from the desktop, had to find a way to move the marble to the opposite end of the maze. As students worked, the teacher circulated and asked guiding questions to the whole class such as: Did the marble always go where you wanted it to go? Why? What force caused the marble to move? What force caused the marble to move in directions often opposite from the way you wanted it to move? Students were then asked to extend their understanding of the inquiry to real life circumstances and explain why people use seatbelts in cars.

Inquiry three, Losing Your Marbles, also focused on Newton’s First Law of Motion. The inquiry challenged students to explore linear motion and centripetal force. Using a raw egg, a hard-boiled egg, a ping pong ball, a rubber ball and a bowl students worked in small groups to answer the focus question: What are some forces that can affect the motion of an object?

The teacher engaged the students by asking questions such as: What happens when a car turns a corner? What happens to the passengers? Why? During the explore stage, students were challenged to identify which egg was hard-boiled and which was raw. After predictions were made, the teacher spun both eggs and used one finger to quickly and gently touch each egg in an attempt to stop the spin. The hard-boiled egg stopped, but the raw started spinning again. Students applied the concept of inertia as they continued to the next part of the inquiry.
The teacher asked the whole class how they could make a ball move around inside a bowl. Students manipulated both the rubber ball and ping-pong ball inside a bowl held upright and upside down. Students observed the path of the ball both ways to determine what happens to the balls when the upside down bowl was removed from desktop. This inquiry was extended by asking students to identify paths of motion common in their daily lives such as a rabbit hopping, a pendulum swing, or a skateboarder going down a ramp.

Inquiry four, Hide and Seek Energy, continued the development of conceptual learning of inertia and potential and kinetic energy. In this inquiry students explored the amount of energy spent by a ball dropped from knee height and head height.

Using a tennis ball and a large pan filled with wet sand student groups dropped the tennis ball into the sand from various heights. Students observed and measured the dents made in the sand by the impact of the ball. The teacher guided conceptual development by asking questions to the whole class such as: Which ball had more energy when it hit the sand? What evidence do you have to support that? When did potential energy transform to kinetic energy? Having groups generate a list of follow-up questions to investigate could have extended this inquiry: What would the results be if a different ball were dropped? What would happen if the balls had different masses?

In inquiry five, Bouncing Balls, Newton’s Laws of Motion continued to be explored. This inquiry used a series of various balls to test the concepts of friction and gravity. During this inquiry, students considered the focus question: What will happen if the same ball is dropped from the same height onto the same surface over and over
again? Students extended their conceptual understanding of potential and kinetic energy as they discovered the ball bounce decreased with each bounce because as the ball collided with the surface, a portion of the gravitational potential energy was transferred into heat energy so the ball had less kinetic energy to continue its movement.

The teacher engaged the students in the lesson by placing a kickball in the front of the classroom and asked students if the ball will move. According to Newton’s first law, it will not. The teacher then held a ball at shoulder height alongside a meter stick adhered to the wall. The students were asked to predict what would happen if the ball was released and the teacher recorded the predictions. In small groups, students took turns dropping a tennis ball from shoulder height and measuring the bounce on a meter stick. As students recorded measurements, the teacher circulated asking probing questions to the class such as: How high did the tennis ball bounce each time? Did all of the balls react in the same way? What made the ball bounce? What is this tendency for an object to resist a change in motion called? When did potential energy transform to kinetic energy? During this period the teacher explained inertia, gravitational potential energy, and reviewed kinetic energy and the laws of motion. Having students predict results of using different balls; ping-pong, small rubber, or basketballs could have extended the inquiry.

The sixth and final inquiry of the study, Rocket Balloons, focused on Newton’s Third Law of Motion, for every action there is an equal and opposite reaction. The inquiry challenged students to ponder, the focus question: What happens to an inflated rocket balloon when the air is released? This inquiry built off the previous lesson and
continued the concepts of potential and kinetic energy and inertia. The inquiry expanded students’ understanding of the third Law of Motion by focusing on action and reaction forces.

The teacher engaged the students by holding an inflated balloon in the front of the class. While the balloon is clamped, the teacher asked the students how they could move a balloon from one end of the room to the other. Several students were asked to demonstrate. Then the teacher asked the class what would happen if the air was released from the balloon.

Students explored the concept of action and reaction forces, along with Newton’s Third Law of Motion as they worked in teacher prescribed teams. Students used four different sized balloons, a straw, masking tape, and string to conduct the inquiry. The teacher selected one team to model the set-up of the rocket balloon track. Two students held the string taut at shoulder height; one inflated a balloon, but did not tie it, and attached the balloon to a straw, through which the string has been threaded. The fourth student acted as launch coordinator and told the student when to release the balloon and then recorded the distance the rocket balloon traveled across the string. Students rotated through all positions, each with a different sized balloon and repeated the process.

As students were launching their balloons and recording their data, the teacher circulated to each group to ask the class about their observations. Questions included: What caused the rocket balloon to move along the tracks? When did an energy transformation occur during the activity? How did balloon size affect the flight? Which of the four balloons traveled the greatest/shortest distance? Why do you think so? What
other variables may have affected the distance the balloons traveled? Challenging students to change the angle of their track or to hold the line vertically rather than horizontally may have extended the inquiry.

**Small-Group Observations**

Observations were conducted to note the students’ discourse and participation in science inquiries. Observations occurred during inquiries scheduled by the teacher and researcher in the science lab over a four-week period, during the 2009-2010 school year when students were working on inquiry-based force and motion explorations. Six observations per class occurred during the study.

In each observation, an observation protocol was followed. The protocol was a modification of Amidon’s 1996 Verbal Interaction Category System (as cited in Schmuck & Schmuck, 2001) and incorporated Cohen’s suggestions for productive small groups (1994). The protocol was divided into columns. The left contained descriptive notes while the right column contained reflective memos (Creswell, 2007) (Appendix O).

**Small-Group Transcripts**

One randomly selected group from each classroom was observed during each inquiry. The group selected prior to the first lesson was targeted for all remaining lessons. During the observations the observed group also had a voice recorder recording the discourse. Recordings were transcribed verbatim using pseudonyms. Unclear mumbling and remarks were omitted from the transcription to make discourse more apparent.
Interviews

Student interviews were scheduled following the second and last observation session of each class. All students from the observed small group activity were interviewed. During interviews, an interview protocol was followed. The interview protocol provided space to record interviewees’ responses and additional notes as needed (Creswell, 2007) (Appendix P). Participation in the interview was voluntary and there was no penalty for nonparticipation.

Interviews were recorded. Interviews were transcribed omitting unclear mumblings and phrases to make the students’ ideas the focus of the work. To increase validity students were given copies of the transcripts and the researcher read the interview back to the students to ensure transcriptions were accurate. Students were advised they could add or clarify as they wanted. None of the student participants modified their responses after the reading of transcriptions. Data from the interviews provided evidence of the nature of students’ oral discourse while in small groups and connections between oral and written discourse in science notebooks.

Qualitative data may be collected through three basic interview approaches: informal conversational, general interview guide, or standardized open-ended interviews, each with their own merits and shortcomings (Fontana & Frey, 1994). The standardized open-ended interview, with carefully and fully worded questions was selected for this study. The use of scripted questions ensured each child was asked exactly the same sequence of questions. The scripted questions further kept the interview to an acceptable duration. This was an important part to the study. As an invited guest into a colleague’s classroom being aware of time impositions was critical. The interviewees were also
sensitive to time management issues as they were ten and eleven years old and did not have an attention span to sustain lengthy or abstract interviews. Using the open-ended interview for this study on elementary discourse in science class met Patton’s outlines of major reasons for open-ended interviews: (a) exact instrument is available for inspection, (b) interviewing is highly focused so interviewee time is used efficiently, (c) analysis is facilitated by making responses easy to find and compare (2002).

**Science Notebooks**

While Patton (2002) cautions documents may be incomplete, their analysis provides additional information that may not be apparent from observations or interviews alone, but instead help to corroborate interviews and observations when triangulated. Data were obtained through small group transcripts, group observations, and student notebooks. Student science notebooks were classified into two parts, a free response, called a Quick Write, and a guided response template drawn from the work of Klentschy involving seven specific response areas for students (Appendix Q) (2008). Throughout the written notebook entries illustrations of science conceptual learning were sought. Hypothesizing, predicting, explaining, and justifying were looked for as evidence of conceptual learning.

Prior to each lesson, students were read a scripted review of how to use their notebooks. The review was read by the classroom teacher, but scripted by the researcher. Providing a script for each teacher enabled all student participants to receive the exact same instructions.

During the Quick Write, students were asked to tell about the inquiry in their own words with no restrictions from the teacher. Performing a Quick Write was a new task
for these fifth grade students and they needed to be assured they were not judged on their writing, they were not compared to classmates, and there were no right or wrong answers. The Quick Write was simply a tool for learning about each student’s perceptions of learning without group influence.

The second part of the science notebook was more formulaic. To provide each student with the same outline all students used a template to record the seven essential components to effective science notebooks as suggested by Klentschy (2008): (a) question, problem, purpose; (b) prediction; (c) develop a plan; (d) observations; (e) claims and evidence; (f) drawing conclusions; (g) reflection.

**Researcher Notes**

After each observation, the researcher reflected on the experience from the perspective of researcher. During the reflections, the researcher noted unusual experiences that occurred during the observation, such as fire drills, as well as the mood of the classroom and small group, and layout of the room. The notes focused on the research questions looking for the nature of student discourse, the influence of gender in student discourse, and subsequent conceptual learning. The researcher also noted any challenges and perceived successes during the observations.

**Data Analysis**

There is no set formula or how to guide for analyzing qualitative research because the analysis system used is highly dependent on the design and methods of the many different types of qualitative research studies. Patton describes qualitative analysis as a blend of disciplined science, creative artistry, and personal reflectivity that transforms raw data into findings (2002). Patton recommends drawing together all the
data into a case record that includes all the major information that was used during the final analysis. Then using content analysis, identifying core consistencies and meanings. Other than the oral and written discourse and gender analysis discussed earlier in chapter 2 within the conceptual frame, the analysis of all documents collected were analyzed inductively for any emergent and unexpected themes in the data while being mindful of previous research and findings conducted in similar areas.

By selecting one group of students per class for intensive analysis, the robust nature of data from interviews and small group transcripts increased. However, the scope of data of written analysis of student science notebooks decreased in terms of numbers of students. Consequently each research question had a shifting triangulation of data with the main data source changing for each. Because of the shifting between main and secondary data sources, each data set was analyzed multiple times. An overview of general analysis precedes the individual research question analysis procedures.

Data analysis was conducted using the computer based qualitative analysis software Atlas TI version 6. As the process of open coding proceeded themes developed with exemplars and deviate cases to confirm or exclude tentative findings (Strauss & Corbin, 1998). All data were analyzed chronologically by inquiry: inquiry one, Penny Push, first; inquiry two, Motion Notion, second; inquiry three, Losing Your Marbles, until all six inquiries were analyzed.

Prior to analysis all data sources; small group transcripts, student science notebooks, interview transcripts, observation notes and memos were sorted. Data sources were first arranged by inquiry. Within each inquiry, data were classified by teacher, and then sorted by type; group transcripts, science notebooks, interview transcripts,
researcher observation notes and memos. Within each inquiry group, each data source was further sorted by gender. This classification of data sources allowed for tentative themes that spanned all six inquiries to become apparent. Each data set was analyzed multiple times in order to apply data to specific research questions.

**Research Question 1**

What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities? The main source of data for this question was small group transcripts. Interviews and observations completed the data analysis. Small group transcripts were the first data source analyzed. Following analysis of all small group transcripts all student interview transcripts followed by observational notes were analyzed.

**Small-Group Transcripts**

All three group discussion transcripts during the Penny Push observations were transcribed and analyzed to establish tentative themes. Then all observations from inquiry two, Motion Notion were analyzed to confirm or deviate from tentative themes. Next, observations from inquiry three, Losing Your Marbles, solidified general emerging themes. Those themes served as a base for analysis of the remaining three inquiries. Concepts such as elaborate discussion, group status, and prosocial behavior as suggested by Cohen (1994) were used as common oral discourse themes in the transcript analysis protocol (Appendix R). As these and other themes emerged, the second set of small group transcripts, Motion Notion, was analyzed to see if there were common themes between the first and second sets. The process continued until all six group transcripts were coded to solidify broad themes that emerged during the three sets of six transcripts.
Themes from classroom observations did not exclude themes that emerged from other data sources, but served as a baseline for establishment of patterns. The validity of finding was supported by the triangulation of multiple data collection sources: group transcripts, interviews, and observation notes and memos.

**Interviews**

Interviews from each of the target groups were transcribed. Unintelligible words and utterances were omitted from the transcript to make student discourse patterns more apparent. Transcripts were grouped by inquiry, sorted by class, and within each class by gender. Transcripts were imported into qualitative data analysis software. The first interview analysis looked for themes based on the nature of students’ oral discourse. Data on students’ reflections of the group experience and how that experience impacted their understanding was focused on questions one through six and ten of the student interview protocol. Roles students undertook or were assigned, by peers, and the resulting discourse during the group inquiry was analyzed. Patterns regarding concepts such as cooperation, helpfulness, understanding, and arguments were noted (Cohen, 1994). After each analysis, themes were cross-checked with themes from observations and small group transcripts to narrow patterns to more specific concepts.

**Small-Group Observations**

Data from observations were transcribed into documents for analysis. An observation analysis protocol, based on Cohen’s (1994) suggestions for effective groups and Ashman and Gillies (1997) suggested classifications of cooperation, noncooperation, and individual nontask behavior the protocol served as a frame for initial analysis. Throughout analysis, the nature of elementary students’ oral discourse and evidence of
students’ conceptual learning were sought. The documents were imported into ATLAS TI, a qualitative data analysis software program. The preliminary analysis of observation documents focused on the nature of students’ oral discourse.

**Research Question 2**

What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning? Research question two used students’ science notebooks as the primary source of data. Secondary data sources were student interviews and small group observations. All three data sources were triangulated to strengthen findings.

**Science Notebooks**

Documents act as conduits of communication that convey messages from writer to reader (Prior, 2008). In this study the conceptual learning of fifth grade students was conveyed by entries in science notebooks. Although analysis of documents ranged from counting of key words to thematic coding of written discourse and using the NGSSS and NSES standards as goals for conceptual learning this portion of the study was concerned with the expression of students’ conceptual learning. Documents for this work were analyzed using a blend of key words and thematic coding.

Notebooks were collected from each of the small groups. Notebooks were grouped by inquiry, sorted by class, and within each class by gender. They were then analyzed chronologically by inquiry. A document analysis of science notebooks was conducted using Klentschy’s model of effective science notebooks as a protocol (2008). Every notebook entry for each inquiry was analyzed for evidence of predictions,
planning, observations/data recording, claims and evidence, and drawing conclusions as part of the nature of students’ written discourse.

**Interviews**

Interviews from each of the target groups were transcribed with unintelligible words and utterances omitted from the transcript to make student discourse patterns more apparent. Transcripts were grouped by inquiry, sorted by class, and within each class by gender. Transcripts were imported into qualitative data analysis software and were analyzed focused on the nature of students’ written discourse in their science notebook. Interview questions seven through generated data on students’ use of science notebooks and their conceptual learning. After each analysis, interview themes were crosschecked with themes from observations and small group transcripts to condense and solidify emerging themes.

**Small Group Observations**

Small group observations were transcribed into documents for analysis. Documents were analyzed for themes regarding the nature of students’ written discourse. Observation protocol section four framed the initial analysis regarding the frequency and manner in which students used science notebooks during each inquiry. At this stage, this was limited to observable evidence of notebook use throughout or after the inquiry.

**Research Question 3**

What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning? Small group transcripts, as previously detailed, were used as the main data source for research question three. Interviews and notebooks were the secondary data sources.
Because of the interrelated nature of this research question to questions one and two the analysis required the same protocol previously detailed.

**Small Group Transcripts**

Beginning chronologically all group transcripts were analyzed a third time. During this analysis, links between conceptual learning in small group discourse and independent written discourse were color-coded. This required simultaneous coding of student notebooks.

Evidence of patterns between oral discourse and observable evidence of students’ writing, drawing, or referring to science notebooks were coded. Next, documents were analyzed looking for evidence of links between oral and written discourse. For example, if a group discussion is focused on momentum, did students use their notebooks during or after the discussion in any way?

**Science Notebooks**

Science notebooks were first analyzed to see the nature of students’ written discourse based on participation in small group science activities. For example, did notebooks reflect oral discourse that occurred during the inquiry or was the independent written discourse completely unrelated to the group experience? Evidence, as suggested by Mason (1998), may be the connection of new and prior knowledge, explanation or clarification of science concepts, or reflection on scientific theory and attempting to link that information to new situations. Because of the grouping of notebooks by gender, a simultaneous coding of boy or girl occurred as notebooks were studied and coded for emerging common patterns or themes.
Loosely based on Kovalainen and Kumpulainen’s 2005 classifications, concepts such as view sharing, information exchange, detailed explanation, and confirmation of concepts emerged. For example, if a student orally explained a concept, such as potential energy to a classmate, did that explanation appear in either the speaker or listener’s science notebook? If so, that was coded as a link between oral and written discourse.

Student science notebooks were analyzed using themes that emerged from previous data to find patterns, if any, between students’ evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning. Miles and Huberman (1994) recommend the use of a document summary form as part of the analysis of documents such as the science notebook entries. The document summary form put the notebook entries into context, provided a summary, and pointed out significance (Appendix M). Patterns that confirm previous themes were coded according to existing code colors. Data from science notebooks, along with data from group transcripts, interviews, and observations were used to crosscheck and validate findings.

**Interviews**

A third analysis of interview transcripts focused on patterns emerging between students’ evidence of conceptual learning in small group discourse and their independent written discourse in science notebooks. Interview questions seven through ten were the focus for this data. Evidence of conceptual learning, such as students referencing their notebook or using their notebook as a tool to help them explain a concept, such as friction, was noted (Mason, 1998).
Research Question 4

How does gender influence discourse during independent writing and group communication as related to conceptual learning of the science material? Research question four was also closely intertwined with research questions one, two and three. Consequently, the main data sources were interviews, observations, and student notebooks. All previously described data analysis techniques were applied.

Interviews

The fourth analysis of the interview data examined the influence of gender during independent writing and group communication as related to subsequent comprehension of the science material. Previously coded themes were recorded using purple for girl and green for boy. Interview questions one through six and ten provided data on the role gender had on students’ oral and written discourse as related to their conceptual learning in science class. All themes generated from interviews were analyzed with existing themes from group transcripts, notebooks, and observation notes.

Small Group Observations

The final analysis of group observation transcripts focused on the role gender had in students’ oral and written discourses throughout the six science inquiries. Small group transcripts were the main data source. Student interviews and notebooks were secondary data sources. This analysis required the reexamination of all previously coded themes to determine the role of gender in those themes.

Science Notebooks

The final analysis of notebooks also required the reexamination of all previously coded notebook themes. During that reexamination the role of gender was recoded to
examine how it influenced oral and written discourse of students as related to their science conceptual learning.

Summary

This study focused on written and oral discourse in an elementary school classroom. This chapter contained the methodology for the study and data collection instruments. Chapter 1 provided the introduction, background, and significance of the research. Chapter 2 reviewed the literature of science discourse and conceptual learning. Chapter 3 described the methodology used in the study. Chapter 4 shares the results of the study. Chapter 5 offers conclusions, recommendations, and suggestions for further research.
IV. RESULTS

The data analysis process presented in this chapter was guided by a sociocultural perspective that was used to investigate the written and oral discourse in relationship to conceptual learning of grade five students within one science unit (Vygotsky, 1978). The researcher disaggregated the data by gender during a secondary tier of the data analysis process to explore for any similarities and differences by gender and between the written and oral discourse and students’ science conceptual learning. In this study conceptual learning was based on Vygotsky’s Zone of Proximal Development that suggests students’ collaboration with peers helps individuals develop a deeper knowledge base than working alone (1978). Leach and Scott (2003) also indicate conceptual learning is enhanced when students are permitted to combine social interactions and classroom discourse. Together these works framed the theoretical concepts used to draw conclusions for this study.

The researcher engaged in several levels of data analysis required by the nature of the research questions. First, data were segmented into analytical units according to research questions one and two. Segments ranged from an individual word, to simple phrases, to several sentences of discourse (Johnson & Christensen, 2000). Then all segments were coded with inductively named terms to describe the content of the segment. Next, a master list of all codes was created. From this list codes were assigned or reassigned to segments as appropriate by examining data for each research question.
Although the researcher created the subcodes she was mindful of previous research into oral and written discourse. Specifically, for research question one, the behavior categories described by Ashman and Gillies such as cooperation, noncooperation and non task behaviors (1997), and the forms of discourse suggested by Tobin and McRobbie (1999) such as describing, clarifying, and changing ideas served as reference points when examining data for the nature of students’ oral discourse. The work of Shepardson and Britsch (2001) suggesting science notebooks illustrate evidence of conceptual learning by showing imagination, previous experiences, and present science investigation and the suggestions of Rivard (2006) outlining expository and expressive entries in science notebooks as evidence of students’ learning served as guideposts when examining the nature of students’ written discourse for research question two. Table 2 illustrates the levels of analysis of the study.

Table 2

*Levels of Data Analysis*

<table>
<thead>
<tr>
<th>Analysis level</th>
<th>Purpose of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creation of data segments</td>
</tr>
<tr>
<td>2</td>
<td>Assigning of preliminary codes</td>
</tr>
<tr>
<td>3</td>
<td>Creation of master list of codes</td>
</tr>
<tr>
<td>4</td>
<td>Examination of co-occurring codes</td>
</tr>
<tr>
<td>5</td>
<td>Enumeration of repeated codes</td>
</tr>
<tr>
<td>6</td>
<td>Convergence of codes with similar conceptual meaning</td>
</tr>
<tr>
<td>7</td>
<td>Examination of convergence and divergence across all coded data</td>
</tr>
<tr>
<td>8</td>
<td>Examination of previously coded data and student gender</td>
</tr>
</tbody>
</table>
Table 3 details the levels of data analysis pertaining to each research question.

Table 3

Data Analysis Levels for Research Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Research question</th>
<th>Level of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based small group activities?</td>
<td>1-6</td>
</tr>
<tr>
<td>2</td>
<td>What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning?</td>
<td>1-6</td>
</tr>
<tr>
<td>3</td>
<td>What is the relationship between students’ evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning?</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>How does gender influence discourse during independent writing and group communication as related to conceptual learning of the science material?</td>
<td>8</td>
</tr>
</tbody>
</table>

The design of the study was flexible in order to attend to information that emerged as the study took place. The collection of qualitative data created a detailed exploration into the construction of scientific knowledge by fifth grade students based on students’ oral discourse and written science notebooks. Results of data analysis were divided into four sections, one for each research question. Chapter 5 offers conclusions and implications for the study.

This study focused on four research questions.
1. What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities?

2. What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning?

3. What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning?

4. How does gender influence discourse during independent writing and group communication as related to conceptual learning of the science material?

**Data Collection Procedure**

Data were collected during a four-week period in May of 2010. Three fifth grade classroom teachers at Dolphin Elementary, a pseudonym, granted the researcher access to observe their classes during a unit of study on force and motion. Each classroom teacher taught six guided inquiry lessons during the time period. One group of students per class was randomly selected to be the focus of all observations and interviews and was voice recorded during each inquiry session. After lessons two and six all student members of the randomly selected groups participated in a scripted, ten-question interview about their experiences during the lessons.

In total, 15 students participated in the study, eight girls and seven boys all between the ages of 10-12 years. Of those 15 student participants, five were from Dr. Johnson’s class: three girls and two boys; four were from Mr. West’s class: two girls and two boys; and six were from Mr. Green’s class: three girls and three boys.
By selecting one group per class for intensive analysis, the robust nature of data collected and analyzed required using different main and tertiary sources for each research question. Because of the shifting between main and tertiary data sources, each data set was analyzed multiple times by the researcher. Table 4 illustrates the alignment of research questions, data sources, and levels of analysis.

Table 4

*Research Question Data Sources*

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Primary and secondary data sources</th>
<th>Tertiary data sources</th>
<th>Level of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>Small group transcripts, Student interviews</td>
<td>Researcher observations</td>
<td>1-6</td>
</tr>
<tr>
<td>Question 2</td>
<td>Student science notebooks</td>
<td>Researcher observations, Student interviews</td>
<td>1-6</td>
</tr>
<tr>
<td>Question 3</td>
<td>Small group transcripts, Student science notebooks</td>
<td>Student interviews</td>
<td>7</td>
</tr>
<tr>
<td>Question 4</td>
<td>Researcher observations, Small group transcripts</td>
<td>Student interviews</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 5 outlines the order in which the six inquiries were completed during the study. Inquiry, as related to elementary science learning, refers to the skills and activities in which students develop scientific understanding (NRC, 1996). The inquiries will be referred to by name for the remainder of the study.

This study had four research questions that required independent analysis of each of the six inquiries. First, general results pertaining to the research question are discussed. Each of the six inquiries is then discussed as a subsection of each of the four
Table 5

*Force and Motion Fifth Grade Science Inquiries Completed*

<table>
<thead>
<tr>
<th>Inquiry</th>
<th>Inquiry name</th>
<th>Focus question</th>
<th>Key concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Penny Push</td>
<td>How is energy transformed from one type to another?</td>
<td>Force, momentum, potential energy, kinetic energy, laws of motion</td>
</tr>
<tr>
<td>2</td>
<td>Motion Notion</td>
<td>What is inertia and how does it affect the movement of objects?</td>
<td>Force, inertia, potential energy, kinetic energy, laws of motion</td>
</tr>
<tr>
<td>3</td>
<td>Losing Your Marbles</td>
<td>What are some forces that can affect the motion of an object?</td>
<td>Inertia, centripetal force, acceleration, laws of motion</td>
</tr>
<tr>
<td>4</td>
<td>Hide and Seek Energy</td>
<td>Does a ball dropped from knee-height have the same amount of energy as a ball dropped from above the head?</td>
<td>Mass, potential energy, kinetic energy, gravitational potential energy, laws of motion</td>
</tr>
<tr>
<td>5</td>
<td>Bouncing Balls</td>
<td>What will happen if the same ball is dropped from the same height onto the same surface over and over again?</td>
<td>Gravitational potential energy, inertia, energy transformation, laws of motion</td>
</tr>
<tr>
<td>6</td>
<td>Rocket Balloons</td>
<td>What happens to an inflated rocket balloon when the air is released?</td>
<td>Mechanical energy, equal and opposite reactions, laws of motion</td>
</tr>
</tbody>
</table>

Research questions. A brief introduction of the concept addressed by the lesson and students’ discourse within the lesson precedes each inquiry subsection. Following that, the individual specific results for each of the six inquiries are detailed by main and tertiary data sources which vary by research question. The final portion of each subsection, research observations, offers a brief summary of students’ conceptual learning within the specific inquiry.
Evidence of conceptual learning was first based on Vygotsky’s theory that in order for learning to occur ideas must first be presented in social situations through various communication modes such as talking, gesturing, and writing. As the exchange of ideas occur, individuals attempt to make sense of those ideas and reflect and individualize their understanding (1978). Through this process students’ conceptual learning may be defined as the ability to ask and answer questions as well as describe, explain, and predict scientific phenomena (NRC, 1996). From these broad ideas of conceptual learning, the researcher narrowed the focus to what fifth grade students should be able to do and articulate. The NSES and the NGSSS were used as sources documenting what students should know and be able to do in fifth grade. According the NSES students should be able to:

- Develop descriptions, explanations, predictions, and models using evidence
- Think critically and logically to make the relationships between evidence and explanations

The NGSSS Benchmarks outline the science concepts that should be accessible to fifth grade students:

- Identify familiar forces that cause objects to move including gravity acting on falling objects
- Investigate and describe the greater the force applied to it, the greater the change in motion of a given object
- Investigate and describe the more mass an object has, the less effect a given force will have on the object.
- Investigate and explain that when a force is applied to an object but it does not move, it is because another opposing force in the environment is acting on it so the forces are balanced.
- Investigate and explain energy has the ability to cause motion or create change.
- Investigate and describe basic forms of energy (FLDOE, 2010).

The outlined concepts above combined with discourse classifications suggested in past research (Ashman & Gillies, 1997; Tobin & McRobbie, 1999) provided the frame for analysis of students’ conceptual understanding in the present study. The present study involved students’ oral and written discourse and it must be noted that while there are no rules for discourse analysis there must be a point to the analysis. The point of the examination of discourse in the current study was to understand how students’ words, both oral and written, impact their conceptual learning of science content. The current study did not address the grammatical or syntactical aspects of discourse. Rather, it addressed two of the seven realities outlined by Gee that are used in both oral and written discourse (2005). One reality discourse contains is relationships. Discourse is a tool used to build relationships between those engaging in the discourse (Gee, 2005). In the present study, the relationships that emerged during small group discussions, including that of self-appointed leader, were noted. The second of Gee’s discourse realities the study focused on was connections. Connections the students made with each other and the science content were analyzed in this study.
Specifically, how the phrases used by the students showed their understanding of the science concepts were analyzed.

**Research Question 1**

What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities? Data for this research question were gathered using two main data sources: small group transcripts, student interviews, and one tertiary source: researcher observation notes. Data were segmented by research question and coded inductively by the researcher, however, the general concepts for preliminary codes stemmed from existing research. Specifically, the work of Ashman and Gillies (1997) who expressed behavioral classifications of student discourse and Tobin and McRobbie (1999) who suggested types of discourse that may impact conceptual learning were used as guideposts.

Subcodes were loaded into Atlas TI software. To identify these subcodes, all three transcripts of student discourse from each of the six inquiry lessons from classroom observations were analyzed for general repeated expressions, such as cooperation, arguments, and bossiness. Then the two 10-question interviews of all 15 students were analyzed using the same subcodes generated from analysis of the group discourse transcripts as guideposts while maintaining flexibility to add new codes as they emerged. Finally, all researcher observation notes were analyzed using the existing and again maintaining flexibility to add new subcodes as they emerged. These steps follow the data analysis Hatch (2002) suggested by proceeding from the specific to the general understanding by beginning with specific elements and finding connections between them. Bogdan and Bilken (1998) also support the inductive data analysis conducted in
this study because as smaller pieces of evidence are analyzed the interconnected nature of the pieces emerge to create sound, data based concepts.

The general existing and emerging codes were the baseline for analyzing the five remaining science inquiries. Each of the remaining inquiries followed the same data analysis procedure: group discourse transcripts, interview questions, and researcher observation notes. By using multiple data sources and methods information was crosschecked to show corroboration (Johnson & Christensen, 2000). The student interview had a total of 10 questions; however, only questions one through six and ten were used in the analysis of the nature of student discourse because they were expressly created to examine the nature of students’ oral discourse (Appendix P). Questions seven, eight, and nine were used as data for other research questions.

After all six inquiries were coded, there were three major oral discourse codes that developed into repeated categories about the nature of student discourse and conceptual learning. These three categories represented groupings of previously described codes, such as cooperation, confrontations, and off task conversations into specific categories classifications that more expressly described student discourse within the science inquiries. Findings were ultimately described thematically using benevolent discourse, assertive discourse, and side talk. The researcher named the first two categories based on codes established from data analysis and side talk was previously established by Lemke (1990). Cumulatively, these three types of discourse illuminated variations of students’ conceptual learning as they completed a unit on force and motion.
Using the Object Crawler tool of Atlas TI small group transcripts, student interviews, and researcher observations were explored again to note prevalence of frequently used one-word phrases in both benevolent and assertive discourse.

Throughout all six inquiries, students used benevolent discourse to support classmates with encouraging words when they were impressed with ideas and knowledge. During one inquiry, one student’s compliment illustrated this theme, “Yeah, that is a good idea.” Conversely, when students felt classmates were impeding their learning, a quick assertive statement was issued to try and stop the impendence such as “Stop” or “Don’t do that!” Using both types of discourse, students were attempting, in a limited manner, to either promote thinking or action they believed to be helpful in their conceptual learning, or to stop actions or discussions they felt were impeding that learning. Table 6 describes the frequency of each of the three discourse themes found within all data sets.

Table 6

Total Data Sources Applicable to Research Question 1

<table>
<thead>
<tr>
<th>Discourse type</th>
<th>Data source</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benevolent</td>
<td>Group transcript</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Researcher observations</td>
<td>55</td>
</tr>
<tr>
<td>Assertive</td>
<td>Group transcript</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Researcher observations</td>
<td>39</td>
</tr>
<tr>
<td>Side talk</td>
<td>Group transcript</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Researcher observations</td>
<td>5</td>
</tr>
</tbody>
</table>
Figure 1 shows the frequency of the most commonly uttered benevolent phrases during all six inquiries. Figure 2 offers a summary of the most common assertive terms students’ used in small group discussions.

**Figure 1.** Supportive words in benevolent discourse.

**Figure 2.** Authoritarian words in assertive discourse.
Nature of Students’ Oral Discourse

During the four-week study, the most prevalent communication in all student groups was benevolent discourse. Benevolent discourse included researcher-named components of compromising, cooperating, and encouraging. Students regularly used benevolent discourse to aid in their conceptual understanding of science topics for each inquiry. Examples of benevolent discourse to aid conceptual understanding included: compromising to reach consensus on making a claim based on evidence in the inquiry, sharing ideas on how to build or improve set-ups for each inquiry, and encouraging classmates to share ideas. An example from a group transcript showed the encouragement of ideas, “I think we should plan it out on paper then actually do it,” was supported with encouraging words from group mates, “Yeah, that’s a good idea.”

Although benevolent discourse was the most frequent in the students’ small group discussions, its opposite, assertive discourse was the second most frequent theme. Assertive discourse contained elements of power and group status. Assertive discourse included arguing and speaking with authoritative commands. Arguing between students was simple and resolved quickly. The main theme of the arguments was related to power in the group such as who did what, how things were done, and how responsibilities were established. Other authoritarian statements indicated the speaker’s status in the group, specifically the status of emergent leader. Examples of the assertive authoritarian discourse from group transcripts include: “No, you’re not going to do that”, “You have to hold it like this”, and “I’ll do it.” The researcher-named components of assertive discourse included: arguing, authoritarian commands, and confrontational statements.
The final discourse, side talk, was the most infrequent. When students engaged in side talk, it appeared to serve as a distraction to the learning. Table 7 illustrates how all three discourses were present in all six inquiries.

Table 7

Frequency of Data Sources for Discourse Classifications

<table>
<thead>
<tr>
<th>Inquiry</th>
<th>Discourse</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Transcripts</td>
</tr>
<tr>
<td>Penny Push</td>
<td>Benevolent</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Assertive</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Side talk</td>
<td>4</td>
</tr>
<tr>
<td>Motion Notion</td>
<td>Benevolent</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Assertive</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Side talk</td>
<td>10</td>
</tr>
<tr>
<td>Losing Your Marbles</td>
<td>Benevolent</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Assertive</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Side talk</td>
<td>2</td>
</tr>
<tr>
<td>Hide and Seek Energy</td>
<td>Benevolent</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Assertive</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Side talk</td>
<td>4</td>
</tr>
<tr>
<td>Bouncing Balls</td>
<td>Benevolent</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Assertive</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Side talk</td>
<td>4</td>
</tr>
<tr>
<td>Rocket Balloons</td>
<td>Benevolent</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Assertive</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Side talk</td>
<td>0</td>
</tr>
</tbody>
</table>

The first inquiry, Penny Push, showed similar frequencies of both benevolent and assertive discourse. However, in the third inquiry, Losing Your Marbles, and the fourth inquiry, Hide and Seek Energy, there were nearly three times as many episodes of
benevolent discourse than assertive. The final inquiry, Rocket Balloons, did not have any transcripts due to the students’ volume in the science lab overwhelming the voice recorder.

Student interviews were purposely excluded from the table because they were conducted only twice: once after the Motion Notion inquiry and once after the final inquiry, Rocket Balloons. Figure 3 shows the correlation of interview data to discourse type.

![Discourse Types in Interviews](chart)

*Figure 3. Students’ articulation of discourse types during interviews.*

**Science Interviews**

The following six inquiries are broken into data source subsections. Each inquiry description contains a compilation of data excerpts to illustrate the discourse most commonly used by students in that inquiry. Based on overall frequency of discourse type in each inquiry the examples below have been arranged to illustrate episodes of each of the three discourse types: benevolent, assertive, and side talk.
Penny Push and Motion Notion are used to provide examples of assertive discourse because they had the most plentiful examples of students’ assertive discourse used to facilitate their learning in student transcripts, student interviews, and researcher observations. Losing Your Marbles and Hide and Seek Energy, based on the frequency of benevolent discourse, exemplify students’ use of benevolent discourse to guide their conceptual development. Motion Notion, despite its high frequency of benevolent exchanges is not used to illustrate the use of benevolent discourse because it is used to examine assertive discourse. Bouncing Balls is used to examine the use of side talk with groups. Finally, because fifth grade students do not speak in only one discourse type, the last inquiry, Rocket Balloons blends of all discourse types during one lesson.

**Penny Push.** In the first inquiry, assertive discourse was used slightly more often than benevolent discourse. The depth of communication varied by student participant and ranged from the simply stated, “No. Stop.” To slightly more complex assertive statements of, “I told you it goes here.” Students using assertive discourse in this inquiry were struggling to find common ground with classmates on responsibilities within the lesson. The relatively simplistic nature of the inquiry combined with few supplies contributed to the use of commands and confrontations throughout the lesson. The assertive discourse was used primarily to establish procedures and group organization and was not focused on the science concept of the lesson.

In this inquiry, students were challenged with refreshing their understanding of potential and kinetic energy and how energy is transformed between objects. According the NSES and NGSSS students should be able to think critically and logically about the relationship of the supplies in this inquiry, specifically the evidence of coins moving
other coins when a force is applied to explain the concept that forces cause things to move. The following episodes from small group transcripts, student interviews, and researcher observation notes showcase the assorted types of assertive discourse including confrontational statements, authoritarian commands, arguments, and complaints students used as they tried to work cooperatively to complete the introductory inquiry.

**Group transcripts.** Assertive confrontational statements were offered relatively early into the inquiry when one student felt the task was too simple. Assertive confrontational statements were uttered quickly and with very little extended dialog between students. Assertive confrontational statements were said to evoke a reaction from an intended group mate. Most commonly the intended recipient offered one of two responses as seen in the following examples:

Matthew: This is easy.

Madison: Matthew, I know everything is easy for you. I know you get straight As on everything.

Cara: It’s OK Madison.

One student’s assessment of the task was taken as an insult by a group mate who offered a sarcastic response. The original speaker ignored that statement. However, another group mate quickly responded with an attempt to redirect the communication away from the assertive discourse. In this case, the researcher is making an inference based on being present during the student exchange. Arousing a confrontation as the objective seems apparent because once the statement was issued the speaker did not continue the confrontation when there was little to no reaction from the intended group mate.
Another confrontational statement offers an example of a brief retort by a classmate.

Ava: Wait. Let me tell you what I [emphasis] think we should do.


Ava: Stop fighting with us.

In this example, one student was eager to share her theories on how to set up the supplies for the inquiry. However, the assertive nature of the discourse with the tone and stress on the individual’s thoughts was problematic for others in the group. The impact on learning is unknown because there is no way to know the outcome of Ava’s never expressed idea and its impact on the inquiry. Evidence of assertive discourse in small group transcripts suggests students’ speak assertively, in this first inquiry, as a tool to communicate organizational and procedural aspects of the inquiry.

*Student interviews.* When students were engaged in work or conversations with peers they disregarded the more soft-spoken members of the group. One student explained, “When they are doing something they don’t listen that much. When someone is making something or talking to someone else they don’t listen.” Another student said, “Sometimes [they listened to me] but I don’t really give ideas cause [sic] their ideas are better than mine.” Sometimes, students felt they had to guide group mates by speaking assertively, “I had to tell Bryan not to do the test until we had all the circumferences measured.”

This data suggests the role of emergent, self-selected leader within the group may influence students’ conceptual learning. Students were not assigned roles or leadership positions within small groups. The role of leader, when it emerged, was created by a
student within the group based on his or her actions and discourse to peers. It is unknown if the more reserved of the students within the small group offered ideas, how those ideas may have influenced the group’s learning. It is also unknown how the group’s conceptual learning could have improved, if at all, if those assuming leadership roles made a point of getting participation and input from all group mates.

**Researcher observations.** Results from analysis of researcher notes indicated students would try to speak assertively when they felt they were not given equal opportunities to participate in the inquiry. For example, “You’re not letting me do anything!” Similarly, if students felt they had too much responsibly and their group mates were not sharing the workload, they would assert themselves, “Look, we are doing all the work. You need to help too.” As other data sources indicated, assertive language was used to promote group procedures and organization and did not revolve around the lesson concept. These episodes of assertive discourse illustrate the need for students to be taught to effectively communicate with each other to share and learn from those exchanges. In this study, students dismissed or ignored each other’s assertive components without any thought to how they might be helpful to their understanding of the assignment or science concept.

**Motion Notion.** The second inquiry had more supplies and was more procedurally complex than the first. The lab, which could have been completed in two days, was condensed into one one-hour setting that made the need for effective communication and cooperation necessary. However, this was not the case. Within the class period, students were challenged to refamiliarize themselves with inertia and how it affects the movement of objects. Frustrations with the set-up of the inquiry, job
responsibilities within that set-up, and time constraints led to frequent use of assertive discourse. The types of procedural and task focused assertive discourse led to the completion of the task, but did not specifically focus on conceptual learning as outlined by the NSES and NGSSS. However, the discussions of set up could contribute to inferences that students were learning about the concepts of inertia, force, and mass as they made a maze and used that model to explain the path a marble should take as it traveled the student-made course.

**Group transcripts.** In the following excerpt, two students were planning the construction of a maze that was used to understand inertia and how it affected the movement of objects.

Mike: We need more straight lines.

Olivia: Which way?

Mike: Straight.

Olivia: Straight can go this way or this way [vertical or horizontal].

Mike: This way [diagonal].

Olivia: You can’t go diagonal.

Mike: Why not?

Olivia: Cause [sic] when do you ever see diagonal on a maze?

Mike: That’s true.

Mike: So draw one straight line with four or five off to the side that it would have to go down.

Brad: Then you’ve got this space so you could draw another one there.

Olivia: It looks really hard.
Mike: Make one go all the way down there and then stop.

Olivia: OK.

Throughout this excerpt, Mike is asserting his beliefs on what is required to make a complete and correct maze. At first Olivia is not sure, but ultimately agreed. A third member of the group joined the conversation and offered his own suggestion. Contrary to episodes in Penny Push where students ignored or dismissed their classmate’s assertive statements, here students challenged one another to articulate why they made such statements. When the group agreed the logic was sound, they agreed to build the maze as suggested which ultimately showed they had a basic understanding of inertia and what would be required to move the ball along the maze and the communication of scientific ideas is part of the NSES.

The following examples represent common disputes where students disagreed about lab set-up and supplies and that disagreement led to a clarification of understanding. After seeing the logic in her classmate’s statement, one student realized she was wrong and agreed to use the correct ball. Had this not occurred, the outcome of the inquiry would have been different because the ball would not have moved as freely around the maze and that could have impacted the entire group’s understanding of inertia.

Andrew: Let’s try this again.

Matthew: It has to go here.

Madison: No, it doesn’t.

Matthew: Yeah, it does.

Emily: Alex is our tester.
Emily: Where is our ball?

Madison: This is our ball.

Andrew & Matthew [simultaneously]: No!

Matthew: It’s too big.

Cara: What about this?

Matthew: No! It’s too big.

Cara: Well, what do we use?

Cara: This one? [marble]

Matthew: Yeah, OK.

In this episode the nature of students’ assertive discourse benefits the learning in the group. This example blends the procedural and organizational aspects of assertive discourse with conceptual understanding to yield a positive outcome for the group’s learning experience. Without the back and forth exchange of ideas, students would not have agreed on the correct material to use and then the outcome of the inquiry would not have provided the intended goal of a basic understanding of inertia.

**Student interviews.** During interviews, students expressed frustrations and perceptions of classmates speaking assertively, particularly when it influenced their participation and understanding of lessons. One student explained, “I would change Emma because she never really helps. She just does whatever she wants to do. I would put Samantha in. If she [Emma] doesn’t get her way she just sits back and says fine you do it and I’ll watch you fail.”

In another interview, one of the boys expressed his frustration with not having a job in the inquiry. “I tried to help build the maze but the girls wouldn’t let me. They said
all the jobs were done. The next lab everyone had a fair job though.” In both cases, students were concerned they would not have ample opportunity to participate and understand the lessons. However, the students’ focus was on the procedural aspect of the lesson, not the conceptual learning associated with the experience.

**Researcher observations.** The Motion Notion inquiry was the only one in which two of the three randomly selected groups were entirely dominated by girls speaking assertively to boys. From the beginning of the first lab, the girls (2) commanded boys (2) to act as assistants rather than peers. One of the groups of girls told the boys, “Get me the scissors,” and assigned jobs to the girls in the group, “I’ll cut, you glue, and you hold.” In the second group, consisting of 6 students; 3 girls and 3 boys, the girls immediately began cutting and gluing without including the boys. The boys gathered behind the girls and watched briefly before engaging in off-topic conversations. In both cases, because the boys were excluded from active participation and discussion, their conceptual understanding may have been impeded.

**Losing Your Marbles.** In the third inquiry students were challenged to expand their understanding of paths of motion and forces that affect the motion of objects. This inquiry illustrated various episodes of benevolent discourse as students worked in groups. Benevolent discourse had components of cooperation, compromise, and encouragement. The use of benevolent discourse aided students in quickly gaining consensus on a particular topic and then proceeding to the next step of sharing ideas to develop conceptual learning. In addition to the sharing of ideas to develop understanding, students were also communicating basic science explanations as outlined in the NSES.
**Group transcripts.** Benevolent discourse during Losing Your Marbles was regularly very short and concise. In this inquiry the students readily agreed to the work arrangements therefore a greater amount of class time was spent on discussing the inquiry, not arguing over who did what.

Sara: Here. I’ll drop the ball and you record it.

Brad: OK.

Regularly, the use of cooperation and compromise led to students reaching a consensus on assigned topics. Students discussed the use and order of supplies to be tested during the inquiry.

Emma: Ok you do the ping-pong ball.

Ava: No, I want to do the green one!

Emma: No, I’m doing the green one!

Joshua: You guys! Let’s just go.

Emma: Fine. We can both do the green, but I want to go first.

Ava: Fine, but next time I go first.

Through the use of compromise students showed they understood the focus of the lesson was not on who used which supplies, but rather the actual manipulation of supplies to help them understand the motion of objects. When examining the nature of students’ oral discourse in inquiry three, Losing Your Marbles, the benevolent discourse led to consensus among the group and sharing of ideas that led to establishing a basic understanding of paths of motion and the amount of force required to move objects along those paths.
**Student interviews.** One student illustrated the importance he and his group felt about the art of benevolent discourse. “People said ideas that would be effective and others said no, but eventually we compromised and found solutions.” Another student acknowledged working in groups is not always easy, but everyone found a way to get along. “Because it is interesting to work with other people we can get through the tough times and arguments we have to make sure we get everything done.” A third student pointed out, “Working with the group is good because they are smart. They are good at cooperating with each other. They help me understand something. Like I didn’t know what inertia meant.”

These examples illustrate students’ perception that working with peers is beneficial to their conceptual understanding of science topics. However, students rarely cited specific ways in which talking with their group mates helped them understand the science lesson. This might be due to the structured nature of the interview questions. It might also be attributed to the students’ limited metacognition. When asked to explain a response further the usual reply was a shrug or, “I don’t know.”

**Researcher observations.** Self-assigned, emergent leadership roles were evident in benevolent discourse. Through these leadership roles students were able to direct the group on how to proceed as well as attempt to keep the discourse content focused. Leadership was evident in the assigning of roles within groups. “You drop. You measure. We’ll all do the math. It’s your turn.” Leadership was also evident in taking initiative to get the inquiry finished. “Tell me the numbers and I’ll get the average. Hand me the calculator.” The difference between role assigning in benevolent discourse and assertive discourse was the group’s perception of the leader. When the leader was fair
and equally distributed responsibilities, or assumed the most difficult task for him/herself, peers were more likely to act cooperatively and supportively of the endeavor which ultimately may have contributed to a greater understanding of the science concept.

**Hide and Seek Energy.** The fourth inquiry focused students’ abilities to describe and measure the motion of an object specifically using the transformation from potential to kinetic energy as outlined by the NGSSS. This inquiry continued the illustration of students’ use of benevolent discourse including cooperation, compromise and encouragement during the lesson as students attempted to gain greater understanding of energy transformation by describing, explaining, and using models to draw conclusions about force and motion.

**Group transcripts.** In the following excerpt, students cooperated to set up the inquiry and to mutually agree on a manner of conducting the inquiry and observing the results.

Cara: 3, 2, 1. Wait! Turn your foot. [drops ball]

Emily: Wait. Why isn’t this working?

Andrew: I know how to do it. Here. Put your foot this way.

Madison: That’s too high. It needs to be at the knee.

Andrew: Ok 1, 2, 3. [drops ball]

Alex: Don’t mess up.

Matthew: It’s going to have a bigger dent cause [sic] gravity is pulling on it more.

Andrew: True.

Emily: I messed up a little bit, but I can fix it.
Madison: No, just leave it so we can measure.

This transcript excerpt showed the blending of procedural benevolent discourse with discourse that showed an understanding of the scientific principal illustrated by the lesson and the NGSSS. Students worked cooperatively to set up the ball drop, then one student offered a prediction of the outcome of the lesson, and a group mate readily accepted that prediction.

**Student interviews.** Students were pleased when their group worked well together. Frequently, students’ linked benevolent discourse to sharing ideas that improved the learning experience. One student confirmed her group’s ability to compromise throughout the inquiry, “We worked together very well. We all put our heads together and had ideas on how to make the inquiry easier and better.” Another student pointed out the group’s communication helped him understand the focus of the lesson. “When I talk to my classmates and I don’t have the right answer they can help me.” Another student agreed, “Most of the time we all shared answers and worked together nicely and all put our thoughts out there. For instance when I said put a piece here and another said no we would compromise.”

**Researcher observations.** The Bouncing Ball inquiry required students to precisely measure and record their findings in their science notebooks. Students regularly used benevolent discourse when conducting and recording measurements. By sharing measurements with each other, students were able to benefit from the expertise of the group leaders, in this case, those who were measuring. For example, one boy measured the diameter of the indentations in a sandbox made from a falling tennis ball. Two group mates observed that the measuring was accurate. When they all agreed they,
in unison, called out the measurement to a fourth group mate who recorded it in the notebook. Once all the measurements had been recorded, the student that was acting as secretary called out the measurements so all student could have the same information in their notebook. With this sharing of roles, students used benevolent discourse to share and verify information as they completed the inquiry, which ultimately led to drawing of accurate conclusions about gravitational potential energy which is outlined by both the NSES and NGSSS.

**Bouncing Balls.** The fifth inquiry combined all previous science learning including paths of motion, transference of energy, and how inertia, gravity, friction, and mass affect motion. The examples in this inquiry illustrate episodes of side talk that occurred during the force and motion unit.

**Group transcripts.** When students were not listened to, were frustrated with the group, or were left out, side talk began. Side talk either focused on a completely unrelated topic, or was used as a delay tactic that was loosely related to the topic at hand. Off topic statements were sometimes ignored, “Has anyone seen Nightmare on Elm Street?”, or “Why did you do your hair like that this morning?” Others were briefly acknowledged then ignored.

Madison: I’m not the one that got qualified into GEM.

Matthew: That was math.

When ignored, one student briefly persisted in trying to engage in side talk.

Mike: Why does this say I love Sara?

Mike: Why does this say I love Sara? [repeats]

Olivia: Doesn’t matter.
This extended side talk was rare:

Emma: I need a chocolate bar.

Ava: I love chocolate!

Emma: I don’t have any.

Ava: At home I have a ton of candy from a birthday party I went to.

Ava: Remember the candy we ate in Sea World after you ate all the cotton candy?

Joshua: I ate all the cotton candy?

Ava: Yeah.

Joshua: Oh yeah, I ate all of it. I remember that.

Emma: Mr. West wouldn’t let me go in there because he thought my mom wouldn’t be happy with me coming home all crazy.

Other side conversations were loosely related to the assignment and appeared to be used when students were bored, disinterested, or left out of the group. Other possibilities, such as the content being too difficult for the students may also be a contributing factor to the side talk. However, the researcher dismissed that possibility as this was a review of content previously addressed in the school year. In the following example Madison did not need the paper immediately, but rather used searching for it as a distraction to the ongoing inquiry. Cara’s insertion about hot glue was totally unrelated to the inquiry and was not a part of the materials needed to complete the lesson.

Madison: Where’s my paper?

Madison: No, not that paper-the yellow one.

Madison: Oh it’s right here.
Cara: I love working with hot glue.

Madison: Yeah, that would be so much better.

**Student interviews.** Side talk was not a common theme in interviews. However, when it was mentioned it was to report on another student’s actions, not to mention how the distraction impacted science conceptual learning. When side talk occurred, it was noticed by others in the group. “Andrew and Alex didn’t help that much. They walked off and talked to some friends and didn’t help.” Another student offered, “If one person was doing something Joshua would talk with Bryan about something totally different.”

**Researcher observations.** In an interesting turn of events, one instance of side talk developed into a noteworthy learning experience between three classmates. Two students challenged each other by betting which ball, a tennis or ping-pong, would bounce higher. Using the meter stick the teacher had attached to the science lab table, they began their challenge. The student in charge of measuring the height of each bounce noticed a problem with the meter stick. Specifically, it was upside down. Another classmate suggested it was in fact correct due to the manner in which they had to measure the height of the ball drops in the actual inquiry. Without this brief side talk that initially served as a detraction from learning, the understanding of the proper use of the meter stick might have gone unnoticed and the entire results skewed because of incorrect measurement.

**Rocket Balloons.** This was the culminating inquiry where students were expected to show all they had learned during the past four weeks. All three of Newton’s Laws of Motion were present in the lesson. By releasing different sized balloons attached to a straw threaded over string students were expected to incorporate all of
Newton’s Laws in their explanations of their observations. The episodes described here illustrate the mingling of all discourse types, benevolent, assertive, and side talk.

**Group transcripts.** This inquiry was very exciting to the students. As students engaged in the inquiry, their voices became louder and more boisterous. The volume within the science lab became so great the voice recorder was not able to record the small groups therefore there are no transcripts to categorize discourse types in Table 7.

**Student interviews.** The self-assigned role of leader was present as students organized, planned, and tried to stay focused on the activity. In an interview, one student spoke about his leadership role within the group. “In the last experiment we did I was sort of the one that did everything. Everyone else was laughing at the other groups who were popping the balloons so I had to tell them what to do and they listened to me.”

Another student continued to explain the leadership within the group.

It wasn’t really arguing. It was sort of like, for example, I wanted to be the person who blew up the balloon and instead of arguing we took a vote and everyone voted for Alyssa so she got to blow up the balloon. They voted for her because she’s smart and she mostly gets voted for everything. Popularity thing I think.

As leaders emerged in the groups, other students struggled to be heard as illustrated with these interview excerpts. “The girls were hogging the jobs. We [boys] were asking the girls to try to help and they said we are already finished. They weren’t finished, but we didn’t get to help.” Several students expressed the relationship between group status and being acknowledged or listened to within the group during the interview.
Well, I guess I was [listened to], but some people not really. Like sometimes they [the group] liked my ideas, but not other people’s. Because we are friends they listened to me but if they don’t like you your idea won’t work.

**Researcher observations.** Students eagerly and enthusiastically participated in this inquiry. However, the fun, playful nature of the lesson superseded the students’ ability to focus on learning. The experience began simply with assertive discourse used in organizing the set-up, including directional commands such as, “Hold this”, “Cut here”, and “Use that one.” Assertive discourse mixed with side talk contributed to problems in the inquiry.

The lesson called for fishing line to be threaded through a straw and then the balloon attached to the straw to keep the balloon traveling in a straight line when air was released. The problem began as the fishing line easily and quickly became completely knotted beyond repair. This led the groups to complain and assign blame, “I told you not to do that.” The accused responded with, “I’m sorry. I didn’t mean to.” No one from the group came to the assistance of the accused. Rather than try to regain favor within the group the singled out student tried to engage one friend by blowing up a balloon so large it popped. The popping caught everyone’s attention and the side talk began, “That was cool!” and “I’m going to try with this one.” With limited teacher intervention this game continued. At the end of the inquiry students realized they had lost focus and quickly and half-heartedly tried to figure out what they were expected to do, but too much time had passed. The inquiry was over without much learning taking place.
Summary of Research Question 1

The first research question was, What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities? The data collected and analyzed in this study suggested three types of student discourse occurred when students were working in small groups to complete inquiry-based science activities: benevolent discourse, assertive discourse, and side talk. Each type of discourse had a unique impact on students’ science conceptual learning. There was variance among data sources, yet the same three categories of discourse were consistently present in all inquiries. Using affective classifications of oral discourse presented a challenge for the researcher to draw conclusions about students’ conceptual understanding.

Determining conceptual learning based on the nature of students’ oral discourse was complex. Students spoke in short, concise terms and often switched between discourse types within an inquiry. The determination of depth and quality of conceptual learning was left to the researcher’s inference based on in depth analysis of collected data using the NSES and NGSSS as guideposts for what fifth grade students should be able to do in science lessons. The impact of side talk, as well as benevolent and assertive discourses as related to students’ science conceptual learning will be further discussed in Chapter Five.

Research Question 2

What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning? Students’ science notebooks were the main source of data for this research question. Interviews and researcher observations...
were the secondary data sources analyzed for this research question. Notebooks consisted of two parts loosely based on Rivard’s suggestion that science writing occurs in two types: expository and expressive (2006). Expository writing is based on summaries and analysis of science experiment or lesson. Expressive writing is less rigid and may include imagination and feelings about the science experiment. The first notebook part contained four data collection sections suggested by Klentschy: prediction, data, claims and evidence, and conclusions and reflections (2006). The second part consisted of a Quick Write: space for students to create a free-style reflection of their learning and feelings about the inquiry (Appendix Q). Data analysis related to the nature of students’ written discourse while in small group inquiries began with Penny Push science notebooks and proceeded sequentially through the remaining five inquiries. In total, 86 science notebooks were collected and analyzed. First, the data collection portion then the Quick Write portion of student notebooks were analyzed for expressions of science learning as outlined by the NGSSS and NSES and classified into three tiers of conceptual learning: high, moderate, and low as detailed in Table 8.

Table 8

<table>
<thead>
<tr>
<th>Tier</th>
<th>Level of learning</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High</td>
<td>Clear and concise expression of concept</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
<td>Partially correct expression of concept</td>
</tr>
<tr>
<td>3</td>
<td>Low</td>
<td>Flawed or erroneous expression of concept</td>
</tr>
</tbody>
</table>
These classifications were further based on more precise patterns in the data such as use of key science vocabulary and detailed explanations of science concepts. Because of the age and academic experience of the student participants, there is no clear-cut definition of what students’ science notebooks should contain. Consequently, some student notebooks could have been classified into several tiers. When this occurred the most prevalent expression of science concepts was used as the deciding factor. These themes were loaded into Atlas TI software.

After establishing basic patterns, the 10-question interviews of all 15 students were analyzed using the same themes of conceptual learning: clear and complete expression of science concepts, partial expression of concepts, flawed and erroneous ideas, and use of key vocabulary as they emerged. To discover the nature of student written discourse, interview questions, seven through ten were analyzed. Finally, researcher observation notes were analyzed to confirm or contrast existing themes.

Analysis of the students’ notebooks collected over the four-week study indicated students had a basic understanding of the scientific concepts from the force and motion unit but the written explanation of scientific concepts was superficial. For example, all notebooks showed students using the key concept in some way. Most treated the concept like a vocabulary word and inserted it into the prediction. Others tried, with varying degrees of success, to explain the concept in the claims and evidence or conclusion sections of the notebook. All science notebooks had some degree of correct understanding of science concepts appropriate for the particular inquiries based on Big Ideas 10 and 13 of the NGSSS which were adopted by the state in 2008 (FLDOE, 2008). Twelve notebook entries were classified as third tier, containing more flawed or
erroneous information than correct. Table 7 details the results for conceptual learning by inquiry. Figure 4 details the levels of learning evident in students’ science notebooks.

**Figure 4.** Evidence of students’ levels of conceptual learning in science notebooks.

Tier 2, moderate conceptual learning, was the most common evidence of students’ understanding of science concepts particular to each inquiry. It was interesting to note, however, that there was no increase in depth of conceptual learning as the inquiries proceed though the unit, rather inquiries two and three, Hide and Seek Energy...
and Losing Your Marbles, contained the greatest evidence of in-depth, clearly expressed conceptual learning.

Notebook entries will be discussed first by individual inquiry, then by evidence of conceptual learning, specifically Tiers 1, 2, or 3. To be classified as Tier 1 science notebooks students were required to showcase an in-depth understanding of science concepts by incorporating proper vocabulary and in-depth explanations into the notebook components. Beginning with predictions, students showed their understanding by writing well-developed conclusions, both with and without scientific vocabulary. The second tier of science notebook classification was partially correct notebook entries. These entries were classified by the depth and thoroughness of the responses for each notebook section. To be classified as Tier 2, notebook entries had to express a basic understanding of the science concept associated with each inquiry but either missed some depth of explanation or incorrectly used or omitted vocabulary terms. Tier 2 had the greatest number of notebook entries. The final classification of science notebooks was Tier 3. The Tier-3 mistakes ranged in severity. Some were clearly misunderstood directions. In other cases, students responded to the posed question, but omitted the science concept. Some Tier-3 notebooks did not show evidence of any learning, but reflected a hurried attempt to fill in the portions with random science words.

Within each notebook tier, evidence of students’ learning will be presented by subsection of the notebook; prediction, claims and evidence, and conclusions and results (Appendix Q). Data for each section of each inquiry were taken as direct quotes from students’ science notebooks. Following Conclusions and Reflections a brief researcher commentary concludes each section. Data section has been excluded because the data
show students filling in charts with measurements and when that data is taken out of the context of the inquiry does not illustrate the students’ thinking or understanding, but rather appear as random numbers.

**Penny Push**

Fifteen notebook entries were submitted for inquiry one. These entries were analyzed for evidence of conceptual learning related to potential and kinetic energy and the transformation of energy between objects. Tiers 1 and 2 were found in these entries.

**Tier 1.** Prediction: My prediction is the first energy starts as potential and once it is moved it becomes kinetic.

- Claims & Evidence: [claim] I saw kinetic energy was more in the quarter [evidence] because it had the most mass and the most momentum so it collided with the pennies with more force.
- Conclusion & Reflections: I now know that kinetic and potential energy has to deal with momentum, mass, and friction because all of them had to do with size, weight, and roughness of the table. I believe this really taught me more about matter and the properties and energy.
- Researcher Comments: The prediction showed an understanding of the relationship between potential and kinetic energy. Claims and Evidence detailed a clear understanding of concepts and their relation to the observations made in the inquiry. Conclusion and Reflections linked concepts and inquiry to show a clear understanding of the science concepts.

**Tier 2.**
• Prediction: The force that you transfer to a penny is going to transfer to the other penny.

• Claims & Evidence: [claim] I think that the distance depends on the objects mass and the force you used on the object. [evidence] I think that because the quarter is bigger and when I pushed it really hard the pennies went farther.

• Conclusions & Reflections: I now know because when I tried the penny it went far.

• Researcher Comments: The prediction alluded to understanding of transfer of energy, but did not offer that explanation. Claims and Evidence were well developed by including what was observed and tried to tie transfer of energy into the evidence, but fell short of detailing completely. Conclusion and Reflections were poorly developed and did not include any evidence of conceptual understanding of energy transfer.

**Motion Notion**

Fourteen notebook entries were submitted for inquiry two. These entries were analyzed for evidence of conceptual learning related to potential and kinetic energy, the transformation of energy between objects, and inertia. Tiers 1 through 3 were found in these entries.

**Tier 1.**

• Prediction: I think my group and I are going to be moving objects and the objects will keep moving until an outside force acts on it.
• Claims & Evidence: [claim] 1. Gravity was acting on the object. 2. Inertia was acting on the object. 3. An outside force was acting on the object. [evidence] 1. Gravity was pulling the object to the ground. 2. The object wanted to stay at rest but when somebody moved the box the object moved. 3. The border was the outside force acting on the object.

• Conclusions & Reflections: I now know that inertia means an object at rest wants to stay at rest until an outside force acts on it. Inertia acts on any kind of object, not just marbles.

• Researcher Comments: Prediction illustrated conceptual understanding and a connection to inquiry. Claims and Evidence pointed out three main scientific claims and supported each with data from inquiry observations. Conclusion and Reflections started out with a simple restatement but ended with an application to objects beyond the inquiry supplies, which illustrated application of conceptual understanding to other areas.

Tier 2.

• Prediction: I think the marble will get stuck in the glue.

• Claims & Evidence: [claim] I think inertia had an affect on the marble [evidence] because we had to move the box for the marble to change directions.

• Conclusions & Reflections: I now know that inertia had an affect on the marble by going through the maze and inertia moved the marble and we moved the box to change directions.
Researcher Comments: The Prediction related to the expected outcome of the inquiry, not the focus question. Claims and Evidence hinted at an understanding of inertia by describing the need to move the box to change directions, but did not point of the tendency to remain at rest until acted on. Conclusions and Reflections restated the Claims and Evidence with no link between the inquiry and the concepts of inertia, force, or friction.

Tier 3.

- Prediction: My prediction is that inertia helps movement by providing friction for the movement. Also helping gravity by keeping things on the ground.
- Claims & Evidence: [claim] I think that when you move the box I think that you move it in the right direction if you are smart. [evidence] It is harder than drawing [the maze]. You will find ways to win.
- Conclusions & Reflections: I now know that it is more fun pushing than drawing and that inertia really helped the box move the marble.
- Researcher Comments: Prediction showed the student is aware he should use vocabulary, but does not understand the concept and applications of the terms. Claims and Evidence related to how to win, but did not address any scientific concepts. Conclusions and Reflections blended the fun nature of the inquiry with an attempt to incorporate vocabulary, although it is incorrect.

Losing Your Marbles

Fifteen notebook entries were submitted for inquiry three. These entries were analyzed for evidence of conceptual learning related to balanced and unbalanced forces and inertia. Tiers 1 and 2 were found in these entries.
Tier 1.

- Prediction: I think the ball will fly off in a straight line and not continue in a circle.

- Claims & Evidence: [claim] I think that inertia effected the balls [evidence] because it kept the balls moving in a straight line off the table.

- Conclusions & Reflections: I now know that inertia has a big impact on the balls by keeping them moving in a straight line. Your hands and the bowl are the forces that effect the movement and path of the balls.

- Researcher Comments: Prediction indicated the student understood what will happen, but not why it will happen. Claims and Evidence simply restated prediction: There was no link between the observation and scientific principles explaining why it happened. Conclusion was a bit stronger because the student linked the ideas of unbalanced force, but did not properly convey how inertia impacted the path of motion.

Tier 2.

- Prediction: It [the ball] will move in a straight line.

- Claims & Evidence: [claim] I think inertia effected the balls [evidence] because they continued in a straight line after we picked up the bowl.

- Conclusions & Reflections: I now know that inertia effects objects by making them continue in a straight line.

- Researcher Comments: Prediction and Claims and Evidence showed the student understood the ball will continue in a straight path, but offered no
explanation of the science concept that explains why this occurs. Conclusions and Reflections were just restatements of Claims and Evidence.

**Hide and Seek Energy**

Fourteen notebook entries were submitted for inquiry four. These entries were analyzed for evidence of conceptual learning related to two forms of mechanical energy: gravitational potential and kinetic energy. Tiers 1 through 3 were found in these entries.

**Tier 1.**

- Prediction: I think the ball from a lower height will have less energy because from a greater height it has more force and speed.
- Claims & Evidence: [claim] The ball had greater energy from the head drop [evidence] because it was higher it had more potential and kinetic energy.
- Conclusions & Reflections: I now know that the greater the height an object is placed causes gravitational potential energy to be more and the dent will be bigger than from an object dropped from a lower height.
- Researcher Comments: Prediction showed the student had a basic understanding of energy, but did not articulate it thoroughly. The Claims and Evidence incorporated correct vocabulary to illustrate the student was able to link the scientific concept to observations from the inquiry. Conclusions and Reflections extended claims by using gravitational potential energy to explain the size of the impact on the sand.

**Tier 2.**

- Prediction: I think that the height of where the ball drops will affect the dent size. The higher the ball, the bigger the dent.
• Claims & Evidence: [claim] I think the height of the ball matters [evidence] because it makes a bigger dent when dropped from a higher distance.

• Conclusions & Reflections: I now know that the ball builds up energy when it goes higher. All that energy is released when you drop the ball, causing a dent to form. The higher the ball the bigger the dent.

• Researcher Comments: All three sections of the entry indicated a basic understanding of the concepts of mechanical energy and its transformation, but there were no explicit data that explained that concept. The student offered a simple explanation of observations but could not extend that information.

**Bouncing Balls**

Thirteen notebook entries were submitted for inquiry five. These entries were analyzed for evidence of conceptual learning related to potential and kinetic energy, the transformation of energy between objects, friction and inertia. Tiers 1 through 3 were found in these entries.

**Tier 1.**

• Prediction: Every time it bounces on the floor it comes back slower and lower.

• Claims & Evidence: [claim] The ball came back up lower each bounce [evidence] because the friction caused it slow down, which caused it to come up lower.
Conclusions & Reflections: I know now that when you drop a ball the friction on the floor causes it to come up at a slower rate, which causes it to come up lower than the time before because it lost its energy.

Researcher Comments: The Prediction was very basic, but the Claims and Evidence extended the idea of decreasing bounces by offering an explanation of why it occurred. Conclusion and Reflections reiterated friction and offered additional reasons of lost energy to explain inquiry observations.

**Tier 2.**

Prediction: I predict that the ball will bounce up lower each time until it stops because it loses energy.

Claims & Evidence: [claim]I think that the ball bounced lower each time [evidence] because the tennis ball lost energy each time.

Conclusions & Reflections: I now know that energy has an effect on the ball’s bounce. Each time the ball came up lower as friction took place and eventually the ball stopped.

Researcher Comments: Prediction and Claim and Evidence mirrored each other as a simple explanation was offered. Conclusions and Reflections added friction to the summary, but did not offer any extension of the briefly hinted at concepts to show conceptual learning.

**Tier 3.**

Prediction: I believe it depends on the type of surface because if it’s a rocky surface it would bounce and a smooth surface would bounce lower and shorter.
• Claims & Evidence: [claim] I think the bouncy ball jumped higher [evidence] because it had more elastic and it has the median of the masses.

• Conclusions & Reflections: I now know that my prediction is right because the smooth floor made it bounce lower.

• Researcher Comments: Prediction responded to the focus question, but offered no evidence of any prior knowledge. Claims and Evidence hinted at the mass having some importance, but missed the point of the inquiry. The Conclusion confirmed there was no conceptual understanding for this student because the conclusion referred back the prediction, which was not correctly aligned with the development of correct understanding of mechanical energy and the transformation between potential and kinetic energy.

Rocket Balloons

Fifteen notebook entries were submitted for inquiry six. These entries were analyzed for evidence of conceptual learning related to Newton’s First and Third Laws of Motion. The first Law of Motion states: Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it. The Third Law of Motion states: For every action there is an equal and opposite reaction. Tiers 2 and 3 were found in these entries.

Tier 2.

• Prediction: I think the rocket balloon will deflate and fly everywhere.

• Claims & Evidence: [claim] I think that the bigger balloon the farther it goes [evidence] because mine went 272 cm and the biggest one went 483 cm.
Conclusions & Reflections: I now know that the bigger the balloon the farther it goes. When you released the inflated balloon it goes flying down the line and the more air in the balloon causes more force.

Researcher Comments: The Prediction accurately responded to the focus question. Claims and Evidence gave concrete data to support observations, but omitted any mention of why the balloons were traveling or traveling different distances. The Conclusions hinted at the laws of motion, but did not offer detail, so there is little evidence of conceptual learning.

Tier 3.

Prediction: The rocket balloon will ascend [sic] because the air is released quickly.

Claims & Evidence: [claim] I think the balloon with the most air goes slower [evidence] because it has the most mass in the balloon.

Conclusions & Reflections: I now know that an object in motion stays in motion until another force acts on it.

Researcher Comments: Prediction properly responded to focus question. Claims and Evidence were interesting because the student was trying to link current learning with previous knowledge, but missed the point. Despite that, Conclusions and Reflections offered awareness of the Laws of Motion, but did not link it to any part of the inquiry. Subsequently it appeared tacked on without any real conceptual understanding of why.

In the prediction section of the science notebooks students were directed by the classroom teacher to write what they believed to be an appropriate, scientifically based
response to the focus question. Throughout the study, the predictions consistently illustrated a basic understanding of scientific concepts, but lacked detailed descriptions of that concept. Throughout the course of the study, the quality of students’ predictions altered slightly depending on the nature of the inquiry. Several focus questions inspired more vocabulary to be used in the predictions that others. However, even when the vocabulary was used, it was simply listed and not explained or elaborated.

The claims and evidence section of science notebooks showed greater understanding of scientific concepts than seen in the previous prediction section. Students incorporated both scientific vocabulary and simplistic explanations of science concepts into claims and evidence, but rarely expounded on the concept. Throughout the study, students attempted to explain what they observed and attribute those observations to scientific concepts, but regularly fell short of that goal.

Generating conclusions and reflections based on data, claims and evidence was difficult for these student participants. One group out of the three did not complete the conclusions section of the notebook. This class came into the lab after recess and had only one period in which the lab could be completed. Regularly, they ran short of time, but were unable to switch the lab to a different time during the school day. Those who did complete the conclusions, were unable to link focus questions, predictions, claims and evidence to conclusions.

**Student Interviews**

Student participants completed two scripted, ten-question interviews over the course of this study (Appendix P). Questions seven through ten were used to address students’ perceptions of the usefulness of their science notebooks in helping them
understand each science lesson. In the Quick Write section, students had five minutes to
tell about their experiences in the lab. They could write about what they learned, what
they liked, or what they wished they could do differently. The purpose of the Quick
Write was to let the students express themselves and create a picture of the learning
experience from their point of view.

The second component of the students’ science notebook was the data collection
sections that contained four sections outlined by Klentschy: prediction, data, claims and
evidence, and conclusions and reflection (2006). Each of the sections provided space for
the students to respond to the prompts and record their observations and thoughts. The
four sections were analyzed for expression of science concepts, incorrect expression of
science concepts, and use of key vocabulary as related to science conceptual learning.
Within the four sections, claims and evidence provided the most evidence of students’
conceptual learning. The following subsections detail students’ responses in two main
categories: Quick Write and data collection.

**Quick write section of science notebooks.** During the interviews, all students
were asked which section of the science notebook they found most helpful to their
science learning. Eighteen of the twenty-eight students that participated in the interviews
said they found the Quick Write section more helpful to science conceptual learning than
the sections for recording data. One interviewee explained, “Quick write is good cuz
[sic] you could write about anyone in your group or anything we did.” Another said,
“The quick write is helpful because you can write what you are thinking and how I felt
about working with my group and whether it was hard or fun.” A third student
responded, “The quick write. That’s when you get say whether it’s fun, boring, or easier
or any feelings you had about the group or the lab. The quick write it was easier than the rest, you just write what was fun and what you like. Everything else was more sciencey [sic].”

Despite remarking the Quick Write was helpful to science learning, students rarely expressed how the notebook was helpful. Rather, they indicated the Quick Write was helpful as tool to express themselves, not their understanding of science. The following are typical examples of Quick Writes.

“Losing Your Marbles was a great and fun experience. I give it a 10 out of 10 and rate it A+++.!” Another student wrote, “I thought my group was fair and all got along well. I enjoyed this experiment. It was very entertaining.”

Not all Quick Writes were positive. Some students used the Quick Write to express frustrations and to offer suggestions for improvements. “I think the girls hogged the project and the boys wanted to do some work but the girls didn’t let us do some work.” “I thought that this experiment was challenging. At one point it got boring. We should of used less glue. The cardboard wasn’t sticking very well. The group did yell at each other once or twice.” Although reporting the Quick Write was helpful during interviews, students rarely wrote about their learning experience. Despite the omissions of conceptual learning, the Quick Write was it was beneficial to understand the students’ thoughts about the learning process. Figure 5 illustrates the most common expressions students recorded in the Quick Write section of their notebooks.

Data collection section of science notebooks. Eight students interviewed reported they found the data sections of the science notebook more helpful than the Quick Write for their conceptual learning. One student explained, “On the data sections
you find out more information you left out or probably left out when you were talking about the project.” Another reported, “The data section was more helpful. It helped me by letting me record all the data in the data section and helped me get a better understanding of what we were doing.” Another student linked her oral discussions with a group mate to her science notebook writing, “In the data we can all help each other. The cause and effect in the first lesson I didn’t understand what to do then Alyssa told me and that helped me know what do from then on. I didn’t copy from her, she just explained it so it made sense to me.”

The following are examples of Quick Write entries the students wrote of their learning experience.

I think that this [Penny Push] was a good experiment to learn about force and motion. I learned that the harder you push the nickel, or dime, or quarter, the farther the pennies are going to move. We discussed the conservation of momentum and how and why the pennies move.
Another student explained his learning from the Losing Your Marbles inquiry. “I learned about centripetal force and about inertia. I thought we all worked good together and I also learned about different paths of motion.”

The nature of students’ written discourse was analyzed using three tiers of conceptual understanding: clear and complete expression of ideas (Tier 1), partially correct expression of ideas (Tier 2), and flawed or erroneous expression of the science concepts for each inquiry (Tier 3). Within these tiers the predictions, claims and evidence, and conclusions were analyzed for explanation of science concepts and use of key vocabulary. Basic understanding of scientific concepts was present throughout all entries. However, the detailed explanation of science conceptual learning varied by inquiry. Further discussions of results about the nature of students written discourse are found in Chapter Five.

Summary of Research Question 2

What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning?

Students’ science notebooks were an invaluable tool to assess students’ conceptual learning and their perceptions of that learning. Students struggled to provide detail of their understanding of science concepts, but still reported the notebook as a useful tool. Students also appreciated the Quick Write as a space to express their feelings about the inquiry and their experiences with group mates.

All six inquiries focused on force and motion learning and each built on the concepts addressed in the previous. In the first inquiry, Penny Push, the science concept was the transformation from potential to kinetic energy. This was one of only two
inquiries that all students showed either Tier-1 or Tier-2 learning. Tier-1 learning was classified as clear and concise expression of science concepts, and Tier 2 was classified as partially correct expression of science concepts. Inquiry three, Losing your Marbles, which focused on force, paths of motion, and inertia was the other inquiry that showed no notebook evidence of flawed or erroneous expressions of the scientific concepts covered in the lesson. Inquiry two, Motion Notion, focused on potential and kinetic energy and inertia. This inquiry, along with the final, Rocket Balloons, contained the greatest evidence of flawed and erroneous understanding of science concepts. The fourth and fifth inquiries, Losing Your Marbles and Hide and Seek Energy both focused on transformation of energy and had the greatest number of notebook entries classified as Tier 1, clear and concise expressions of science concepts by students.

**Research Question 3**

What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning? Student interviews and student science notebooks were the main data sources analyzed for evidence of relationships between oral and written discourse. Small group transcripts were the secondary data sources. Interview questions one, and seven through ten were analyzed looking for evidence of relationships between oral and written discourse in terms of conceptual learning. Then the Quick Write section of the science notebooks were analyzed to see if these themes were also present in the notebooks. Finally, small group transcripts were analyzed for evidence of aspects of common themes of benevolent or assertive discourse, as detailed in research question one, such as sharing of ideas, explaining procedures, confrontations, and arguing.
Confirming a link between oral and written discourse required evidence of students speaking and writing benevolently and assertively. For example, if a student reported arguing within the group during the interview, was there evidence of the argument in the notebook, particularly the Quick Write section, and was that argument also found in the group transcript? If evidence was found, the link was classified as benevolent or assertive discourse.

There were two types of relationships that emerged between students as they worked in small groups: cooperation and conflict. Cooperation, part of the previously established benevolent discourse, was the more frequent of the relationships. During an interview one student explained, “Some groups could argue, but we don’t. We all know each other and it’s fun. We come up with decisions on how stuff is done. We vote on who should do it so everyone is happy with what they do.” Another student agreed, “We all cooperated and everyone was nice to each other.”

Conflict, an aspect of previously discussed assertive discourse, was the second link between oral and written discourse present throughout the study. Conflict included two main subsections: unfair responsibilities and leadership roles within the group. Unfair responsibilities included disagreements on who held which job within the group and amount of action each person in the group was able to complete during the inquiry. Similar to disagreements on responsibilities, disagreements over leadership roles were related to how a person in a power position assigned jobs and determined how much each of the other group members would be able to contribute.

The two forms of benevolent and assertive discourse present in both oral and written discourse are illustrated in the following sections, broken down by inquiry. Using
frequency of discourse types (Table 4) the inquiries each illustrate a particular relationship, either assertive or benevolent discourse.

Data from student interviews and notebooks illustrate the link between oral and written discourse. When applicable, excerpts from group transcripts follow to further detail the connections between oral and written discourse as pertaining to students’ conceptual learning.

**Assertive Written and Oral Discourse**

Evidence between oral and written discourse, in the form of assertive discourse, was less prevalent than expected by the researcher. Expressions were not lengthy, nor detailed. When evidence of assertive discourse was found it pertained more to procedural aspects, who did what and how much each individual was responsible for during the inquiry, rather than focused on students’ conceptual learning.

**Penny Push.** Beginning with the first inquiry, there was a small connection between oral and written discourse focused on assertive discourse. The following illustrates two students’ perception of assertive discourse used to communicate group status. Both students were in the same small group, but each noted a different experience of assertive discourse. The first example shows one girl’s perception of assertive discourse with a female classmate regarding roles of power and leadership, which she felt influenced her feelings about the inquiry. She did not mention if the experience impacted her perception of learning.

- Interview: “I think my group did not do well because Emily kept bossing everybody.”
• Notebook: “I think my group got along pretty well, but I think Emily could of let me do more of the work. At the end everything was fine though because it was independent.”

The second example shows one boy’s perception of a classmate’s indifference to the inquiry. The boy hints that if his group mate would have been more interested in the inquiry, the group’s understanding of force and motion could have improved with his input.

• Interview: “The group didn’t work together so well. The girls tried to do everything and the boys were talking over them. Andrew and Alex didn’t help that much. They walked off and didn’t help.”

• Notebook: “I think that Andrew was not paying attention to us and helping our group. He was just talking to his friends.”

• Researcher Notes: Researcher notes indicated, while Andrew was talking with friends, it was after he had been excluded from the group by the girls who assumed leadership roles.

**Motion Notion.** The second inquiry also contained limited evidence of assertive discourse in both oral and written discourse. Group conflicts over unfair responsibilities were typically simple, “You guys aren’t letting me get any work done.” Rarely, the discourse focused on students’ perceptions of how the assertive discourse impacted their conceptual understanding of the science topic, rather they were focused on procedural or organizational aspects of the inquiry.

Some students felt it necessary to take action into their own hands to ensure they had a part in the task. When this happened, classmates were quick to disagree. Initiative
was taken, “I’m going to put the trap door,” and met with resistance “No you don’t!” Other students were more passive about the lack of participation and when they asked for a job and none was given, they did not pursue the idea, but rather watched and then ultimately looked for something else to engage their interest. In both cases, the students’ input could have enhanced the group’s conceptual understanding, but rather than argue their point, the students gave up.

In the following example, one boy focused on the perceived leadership role held by girls within his small group. During the interview and in his science notebook, he expressed both concern over conflicts about group status and the resolution of those conflicts, but did not mention how the assertive discourse influenced, if at all, his conceptual learning.

- Interview: “I’d give us a rating of 1-5 I’d say 3. Cuz [sic] the girls were mostly doing the project and we [the boys] were trying to design. They didn’t vote on it to see if it was fair.”
- Notebook: “I think the girls hogged the project and the boys wanted to do some work but the girls didn’t let us do some work.”

In these first two inquiries, students used limited assertive discourse in both oral and written form to communicate frustration over individual role within the group and perceived leadership roles within the group. Both ideas focused on group procedures and organization, not conceptual learning.

**Benevolent Oral and Written Discourse**

Evidence of links between benevolent discourse in oral and written communication were more prevalent throughout the course of the study, yet data
supporting this link was limited. Evidence from notebooks and interviews suggest students used benevolent discourse to share ideas and suggest ways to cooperate, both of which could lead to greater conceptual understanding, but students rarely explained the communication as beneficial to their science learning.

Data sections of groups’ notebooks presented clear evidence of cooperative exchanges in oral discourse linking to written discourse. Throughout the entire study, each of the three groups wrote the exact same information for each data section of the notebook. However, students rarely wrote or reported the usefulness of classmates sharing ideas to benefit their understanding of observations and data collection.

**Losing Your Marbles.** In the third inquiry, data illustrated students’ perceptions that talking with the group, specifically sharing ideas, was helpful to their conceptual understanding of inertia, force, and paths of motion.

- Interview 1: “If you don’t know a question they [the group] can help you.”
- Interview 2: “They help me understand something. Like I didn’t know what inertia meant and I asked Cara.”
- Notebook: “I liked how the team was working. They were helping others out for some of the time. For like 5 minutes Andrew and Alex were fooling around with the balls.”
- Transcript: Andrew: What’s the average?
  Cara: Average?
  Cara: Well it says mean and mean means average.
  Andrew: Oh yeah.
**Hide and Seek Energy.** In the fourth inquiry, students explored potential and kinetic energy. In this inquiry, one student’s expression of the willingness of peers to cooperate highlights the student’s perception of benevolent discourse. However, that discourse was focused on the procedural aspects of the inquiry, rather than the conceptual learning it may have influenced.

- Interview: “We got along good but we didn’t all have jobs”
- Notebook: “I liked my group because we all worked together. No one got lost in the project.”

**Bouncing Balls.** In the fifth inquiry, students continued to explore a number of topics addressed in previous inquiries such as gravity, potential and kinetic energy, and inertia. In the following examples data suggested a greater attention, by the students, on how discourse influenced their learning, not just their feelings about the inquiry.

- Interview: “Talking to your classmates let’s you come up with new ideas that no one would think of before and together you make a better grade than just independently by yourself.”
- Notebook: “This activity was very interesting to me because I learned that gravitational potential energy is when you are holding the ball and about to drop it. My group had a few disagreements about who would drop the ball and how to set up the chart but we settled that out.”
- Transcript 1:
  Isabella: OK each one of us needs to make our own bar graph.
  Olivia: Ready Sara?
  Sara: Are we doing it together?
Olivia: Yeah.

Sara: Are we doing each one or just the average?

Isabella: Read the paper. What does it say?

Sara: Just the average.

Olivia: What are we going by?

Isabella: Well we have to look at the numbers. We could go by 10s [interval of bar graph].

Sara: No. Fives.

Olivia: Wait. Don’t forget the title.

Sara: What’s our title going to be, Bouncing Balls?

- Transcript 2: Joshua: All right. You ready?

Emma: Yeah.

Ava: No wait. I have to fix it [measuring tape].

Bryan: No.

Ava: It’s upside down.

Joshua: No, that’s right.

Ava: No. It’s upside down.

Joshua: No but when you drop the ball it will be right.

Ava: Why is it upside down?

Joshua: Cuz [sic] when you drop it and it bounces the numbers will tell you how much it bounced. Look. When you drop it will bounce to here. If you switch it will show it bounced 90cm which isn’t true.

Ava: Ohhh OK.
Joshua: All right. Ready?

**Rocket Balloons.** The final, culminating inquiry blended all previously mentioned scientific concepts into one experience. The students loved the experience and consequently were extremely loud during the lesson and no voice recordings were possible. However, students did mention the importance of benevolent discourse with peers for both the procedural and conceptual understanding aspects of the experience.

- Interview: “It’s easier to understand people that are your age. Say, if your friends with them, you will want to listen to them and it’s easier to focus.”
- Notebook: “My group worked well together. We changed the fishing line to the string because it was easier to attach the straw.”

**Summary of Research Question 3**

What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning? Evidence from student interviews, science notebooks, and small group transcripts illustrated the manner in which students used benevolent discourse to help each other understand the science lesson. Benevolent discourse took many forms including helping peers understand directions, teamwork to get tasks organized and accomplished, and helping classmates understand the topic of the inquiry. In addition to helping each other understand the set-up of the lesson, the sharing of ideas and linking oral and written discourse was present in the data section of the science notebook where all group members had the same data noted.

Assertive discourse regularly revolved around group status and equity of responsibilities within the group. The personality of the self-selected leader in the group
set the tone for discourse within the entire experience. If the leader was perceived to be
bossy and self-centered, peers were more likely to challenge or ignore the leader. If the
leader was perceived to be team oriented, the suggestions and ideas offered were more
readily accepted and the group was able to complete the lesson in an organized and
efficient manner.

Throughout the analysis of data, there was some, but not plentiful, evidence of
the relationship between oral and written discourse. Evidence common to both oral and
written discourse related to the NGSSS and NSES for science learning were evaluated.
By crosschecking the data sources triangulation between data sources occurred to
strengthen findings (Johnson & Christensen, 2000). Evidence that was found was more
focused on students’ organizational and procedural concerns, rather than their conceptual
understanding. A discussion of the strengths and weaknesses of these finding is
discussed in Chapter Five.

**Research Question 4**

How does gender influence discourse during independent writing and group
communication as related to conceptual learning of the science material? Researcher
observations, small group transcripts, student interviews and science notebooks were
analyzed for evidence of the influence of gender on oral and written discourse related to
conceptual learning. Using the narrow frame of gender and power dynamics between
participants all data were analyzed (Thorne, 1993). All previously established oral
discourse codes, including benevolent discourse, assertive discourse, and side talk were
examined for gender-based patterns. Science notebooks were examined by previously
detailed data sections: predictions, claims and evidence, conclusions and results, and
Quick Write to determine if gender had any influence on students’ written discourse. Throughout all categories, results indicated gender minimally influenced oral or written communication regarding students’ conceptual learning.

**Gender and Benevolent Discourse**

Benevolent discourse includes evidence of being friendly and kind to classmates. In three categories, cooperation, compromise, and encouragement gender did not play a major role. During the interviews nine students, five girls and four boys, commented on the acts of cooperation in which they were participants or witnesses.

Olivia: Sometimes [we compromised] because Mike wanted to do something different than I did but then I realized his idea was better. At first I said we should make a diagram but then Mike said it was going to be too hard to transport the diagram to the cardboard and we should just do it on the cardboard and I thought it was a better idea.

Bryan: Sometime they say something I didn’t think of. We try it and work on it together.

Seventeen students, five boys and twelve girls, commented on the compromising done within their group. One boy explained, “Sometimes when someone wanted to do the experiment someone else said they wanted to do it too. If there wasn’t enough jobs they took turns.” A girl explained how her group would compromise to complete and improve the lab. “One person would say something and then someone else would add to it to make it better. We would branch off the first idea to make it better.”

Although slightly more girls than boys mention the benefit of benevolent discourse during interviews, when compared with other data, including small group
transcripts, notebooks, and researcher notes, this did not suggest a noteworthy difference according to gender and power dynamics. Additionally, all participants who commented on the benefits of benevolent discourse only referred to its usefulness in assisting the development of procedural aspects of the inquiry, not directly to the conceptual understanding.

**Gender and Assertive Discourse**

Just as there was little evidence of the influence of gender and power dynamics in benevolent discourse, there was no additional evidence of gender influencing assertive discourse. Assertive discourse was minimally found in students’ discussions and included expressions of power statements or commands. For example, a statement such as “Don’t do that! We are not supposed to do that yet” could be interpreted by the members of the group as either a helpful redirection of an incorrect behavior or as a statement issued to show power or control over the group. Depending on an individual’s interpretation, the remaining dialog could be confrontational or the statement could be simply acknowledged without any major response.

During interviews, students were asked how well the group got along during the inquiry. Seventeen students, ten girls and seven boys, reported being part of or witnessing assertive discourse. “We would argue about the design some people wanted to do and how much people were doing.” Six of the seven boys reported assertive discourse and included themselves in the dialog by using collective terms my group or we. Of the ten girls who reported in the same area, five offered the same collectives of my group or we. Five girls attributed the assertive discourse to the boys in the group. “Sometimes when the boys were talking with their friends one of the girls told them to
start working and they argued over that.” Another girl reported, “It [the inquiry] went pretty well. Some boys were fighting and going to a different table and talking to friends and not paying attention.”

Again, slightly more girls than boys mentioned assertive discourse during interviews. However, the difference was so small it could not be considered exceptional. Throughout all assertive dialogs gender and power dynamics did not impact students’ contributions to or learning of science concepts.

**Gender and Side Talk**

Similarly, there was little evidence of gender influencing students’ side talk during inquiries. Most episodes of side talk were short, just a sentence or two between students. According to researcher notes and small group transcripts students who were bored or frustrated with the inquiry used side talk as a distraction technique.

Mike: Why do you have I love Sara on the board?

There is no response, so Mike repeated the question.

Mike: Why do you have I love Sara on the board?

Olivia: Doesn’t matter.

According to researcher notes, this episode of side talk took place during the Bouncing Balls inquiry where the girls maintained control of the supplies and organized the inquiry set up with little to no input from the boys.

All recorded episodes of side talk were equally divided between boys and girls. There was no major influence of gender and power dynamics on the discussions.
Throughout this study both boys and girls used benevolent discourse, assertive discourse, and side talk to communicate their attempts of science learning. Gender had little influence on the dialog or science conceptual learning.

**Gender and Science Notebooks**

During the interviews students were asked how their science notebook helped them understand science lessons. A total of 28 interviews were conducted and 15 girls and 13 boys responded to this question. Of those responses, ten students, five girls and five boys, claimed writing in the notebook helped them understand science concepts.

Ava: I think if you write stuff down it will help you understand better than just keeping it in your head because you have a lot of thoughts in there.

Joshua: I think it helped me understand a little bit more because my group helped me write it and that helped me.

Six students, two girls and four boys, responded writing in their science notebooks helped them remember science concepts.

Bryan: It helps me because we can look back at the data and remember.

Olivia: When something happened you could write it down to remember and use it some other time if needed.

Four students, two girls and two boys, reported the science notebooks helped keep them organized.

Alex: It is more organized so there is a spot for data and predictions and title of the inquiry.

Isabella: It keeps you organized with your information and charts.
Two students, one girl and one boy, explained writing in their notebook helped them explain science concepts.

   Madison: It explained how inertia works and what inertia is.
   Andrew: It helped me because I can explain my thoughts on the paper and know that no one is checking it

Two students, one boy and one girl, reported the notebook was not helpful to their science learning.

   Brad: It’s not helpful because the people that helped me understand the lesson were the people in my group and my teacher.
   Emily: Sometimes [notebooks are helpful]. Not all of them. Some are confusing so I just looked at Andrew’s and tried to fit something in.

Results indicated gender did not influence students’ perceptions of writing in the science notebook to be a useful tool in their science conceptual learning.

Twenty-six students responded to an interview question asking which type of science notebook entry, Quick Write or data collection, they found to be most helpful with their learning. Eighteen students said the Quick Write was more helpful. Ten respondents were girls and eight were boys. The eight students who reported the data section was more helpful were five girls and three boys. Determining preference on which notebook style was most helpful as a learning aid, gender played an inconsequential role.

Using gender and power as the lens through which oral and written communication were analyzed in this study, gender did not have a major role in
determining communication types. Girls more than boys mentioned their perceived differences in communication styles, but only by a small number.

**Summary**

This study focused on written and oral discourse in an elementary school classroom. This chapter contained the data analysis process and results from the study for each research question regarding the nature of students’ oral and written discourse and their science conceptual understanding. Research question one examined the nature of students’ oral discourse in elementary science class. The researcher found there were three main oral discourses fifth grade students used that impacted their science learning: benevolent, assertive and side talk. Research question two examined the nature of fifth grade students written discourse in science class. The researcher found a majority of fifth grade students were able to express partially developed scientific concepts, but regularly lacked the detail and vocabulary to express deep conceptual understanding. Research question three explored links between oral and written discourse and students’ conceptual learning. The researcher found evidence of benevolent and assertive discourse in both students’ oral and written communications confirming a link between the two discourse types. Research question four examined the role of gender in both oral and written discourse. The researcher found gender had little impact on oral or written discourse as pertaining to conceptual learning of fifth grade students. The data analyzed in this study provided information on students’ oral and written discourse as they communicated their science conceptual understanding in both small groups and independently in science notebooks. Implications for classroom practice and suggestions
for future research in the field of elementary science education will be discussed in chapter 5.

Chapter 1 provided the introduction, background, and significance of the research.

Chapter 2 reviewed the literature of science discourse and conceptual learning. Chapter 3 described the methodology used in the study. Chapter 5 offers conclusions, recommendations, and suggestions for further research.
V. DISCUSSION

The study used a socioconstructivist perspective to investigate written and oral discourse as related to the conceptual learning of grade five students within one science unit. This chapter is divided into eight main sections. The first section offers a summary of the study. The next four sections offer conclusions and discussions for each of the four research questions. The sixth section offers a summary of the results of the study. The seventh section offers implications for the elementary classroom. The eighth section offers suggestions for future research in elementary science education.

Study Summary

This qualitative study took place in the 2009-2010 school year. Fifteen fifth grade students participated in the four-week study. The fifteen students were randomly selected by seat assignment in the school science lab. The fifteen students represented one small group from three different classrooms. All student participants had parental consent and completed child assents. The intent of this study was to examine the ways in which elementary school students used both oral and written discourse during science lessons to express their conceptual learning.

During the study, student participants completed six inquiries based on a force and motion unit of study. Throughout the study, students were observed and voice recorded in each small group science lesson and submitted their science notebook entry
to the researcher after each lesson. The fifteen participants also completed two scripted, ten-question interviews: one after lab two and the other after lab six.

**Research Questions**

The research questions for this qualitative study were:

1. What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities?

2. What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning?

3. What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning?

4. How does gender influence discourse during independent writing and group communication as related to conceptual learning of the science material?

**Results**

This study focused on written and oral discourse in an elementary school classroom. The first research question examined the nature of students’ oral discourse in elementary science class. The researcher found there were three main oral discourses fifth grade students used that impacted their science learning: benevolent, assertive and side talk. Research question two examined the nature of fifth grade students’ written discourse in science class. Researcher analysis found a majority of fifth grade students were able to express partially developed scientific concepts, but regularly lacked the detail and vocabulary to express deep conceptual understanding. Research question three
explored links between oral and written discourse and students’ conceptual learning. Evidence of both benevolent and assertive discourse was found in students’ oral and written communications that confirmed a link between the two discourse types. Research question four examined the role of gender in both oral and written discourse. The researcher found gender did not impact oral or written discourse as pertaining to conceptual learning.

**Conclusions**

Conclusions are described according to research question.

**Research Question 1**

What is the nature of elementary students’ oral discourse, as related to conceptual learning, while participating in inquiry-based, small group science activities?

As results in chapter 4 indicated, the nature of students’ oral discourse was classified into three groupings: benevolent, assertive, and side talk. Students all spoke in simple, short sentences. Students never spent time delving into concepts deeply to explain their thoughts or justify their reasoning of particular scientific concepts as suggested by the NSES (NRC, 1996). Rather, students focused on the procedural and organizational tasks associated with each inquiry. This finding is consistent with the work of Bianchini who used a mixed methodology study to examine 80 sixth grade students over four months and two science units of human biology (1997). Bianchini found discussions focused on scientific concepts, applications, and connections were rare while discussions on processes and products were common. Newton, Driver, and Osbourne (1999) found similar results in their study examining seventh through eleventh
grade students during 34 science lessons. Despite the age difference of participants, the researchers concluded there is little in depth discussion related to scientific reasoning.

Results in the present study indicated these fifth grade students only discussed ideas when directed to do so by the teacher. Throughout the six inquiries, classroom teachers used the phrase, “Discuss your ideas with your group.” The students regularly responded to that directive by sharing opinions of what should be done to set up the inquiry and who should be responsible for each part of the lesson. A back and forth exchange of ideas based on the focus question or data observed in the inquiry did not occur. Discussions focused on the technical aspects of task completion, not discussing the scientific ideas behind the work or interpreting the findings. While teachers did circulate in the lab, they offered little input on the quality of students’ discussions. With no formal instruction on how to effectively communicate and no guidance from the teacher, high quality discourse that could positively impact the students’ conceptual learning was limited. Little research into student-to-student discourse at the elementary level has been conducted (Cavagnetto, Hand, & Norton-Meier, 2010). One goal of this study was to contribute to that field.

The researcher was surprised to learn, despite previous exposure earlier in the school year and numerous real world science experiences the student participants had taken part in, they were not able to concisely and regularly articulate their scientific learning both to peers within small groups and to the researcher during interviews. One reason this may have occurred was the students were not able to practice and receive feedback on group discussions. Instead, students spent a majority of the time allotted for science lessons in the traditional teacher-focused schedule that included the Initiation-
Response-Evalulation (IRE) proposed by Mehan. IRE outlines the traditional school day dialog consists of teacher initiating a discussion via question posing, students responding to the teacher prompt, and the teacher evaluating that response (1979). The teacher centered classroom was not a surprise, but consequently students received little if any time to engage each other in quality discourse focused on an exchange of ideas that ultimately led to enhancing science conceptual understanding (Lemke, 1990).

**Oral discourse types and conceptual learning.** In peer-to-peer discourse in small groups, students used benevolent discourse most frequently in this study. Benevolent discourse was used to express support of classmates and ideas generated by peers. These findings are similar to the results of Kovalainen and Kumpulainen who found the most dominate oral discourse for elementary students in science class included the sharing of views, information, and definitions (2005). Benevolent discourse was most common when everyone was satisfied with responsibilities within the group. When all students had equal opportunities to plan, build, and experiment they were more likely to speak kindly with classmates. The use of benevolent discourse may have contributed to students’ conceptual understanding as students shared ideas and worked cooperatively to reach a consensus. The conceptual understanding outlined in the NSES suggests students should have opportunities to develop descriptions, explanations, and predictions using models (NRC, 1996). Regularly, however, the students’ discourse was used to focus on procedural aspects of the inquiry rather than the discussion of scientific concepts. This might be partly due to the students’ age. It might also have been attributed to the fact the students and teachers had not received any training in peer-to-peer communication or effective discussion strategies.
When students were left out or had nothing to do, assertive discourse was used. Assertive discourse included some form of argumentative statements that were believed to advance scientific thinking (Sampson & Clark, 2008). Students were quick to point out ideas, tell each other what to do, or argue about roles and responsibilities within the group, but avoided overt discussions highlighting their scientific learning.

When assertive discourse was used in the small groups, students were not able to use the argument or challenge to foster conceptual learning. Rather than striving to convince their classmates their idea was based on sound scientific thinking, students found one piece of the argument or suggested idea that everyone could agree on and used that to move forward, regardless of if the concept was scientifically sound. This is similar to the finding of Roth and Roychoudhury who studied six Canadian high school physics classes examining the relationship between conceptual learning and concept mapping (1992). Results indicated student discussions typically included either the statement of fact, opinion, or the challenge of one of those ideas. Either by peers’ acceptance or rejection of an idea, the group came to a consensus on an acceptable compromise. The findings also indicated the use of concept maps was a valuable tools for students to use to guide discussions and assist them in using scientifically appropriate language in their discussions. While the population’s age is a major difference between this and the present study, it is interesting to note the similarities in oral discourse findings despite that age difference.

In the present study, students were not observed using any of Toulmin’s model of argument including claims, grounds, warrants, or backing of ideas to express their conceptual learning (1958). Without the use of these argumentative strategies, students
were not able to develop their conceptual understanding in as deep a manner as the researcher hoped. This was concerning when considering the suggestions offered by Tobin and McRobbie that indicate to improve conceptual learning, each child must regularly describe, clarify, elaborate, and review science concepts (1999).

Side talk was the third and least common type of oral discourse observed in this study. When it occurred, it was used as a simple, diversionary tactic offered by students who were not engaged in the inquiry, either by choice or by exclusion by group mates. Only one time during the course of the study did students engage in extended side talk about a recent field trip experience. Most incidents of side talk were one or two sentences that were either completely ignored or briefly acknowledged and then dismissed by one classmate. All members of the focus group were never engaged in a side talk episode that included everyone in the group. When side talk did occur it was between one or two students.

Research in oral discourse has suggested several discussion features that may serve as indicators of students’ comprehension. Authentic questions (Nystrand, Gamoran, Kachur, & Prendergast, 1997), elaborated explanations (Chinn, O’Donnell, & Jinks, 2000), exploratory talk (Mercer, 2000), and reasoning words appropriate to context (Wegerif, Mercer, & Dawes, 1999). In the present study, students were observed only using exploratory talk during small group inquiries. To improve students’ ability to express their learning in a concrete manner they must be instructed on what constitutes quality discourse and how they can use those discourse patterns in their scientific explanations.
While not yet masters of the English language nor interpersonal relationships, students in fifth grade possess enough awareness of both to develop and improve the quality of their oral discourse. One way both these goals could be reached is through regular engagement with teachers that model and provide feedback on students’ extended responses. For example, rather than accepting a student’s response such as, “Friction made the ball slow down.” The teacher could acknowledge the correctness of the response and then offer a more elaborate response such as, “As the ball traveled across the surface the friction created by the ball rubbing against the surface slowed the path of the ball as the kinetic energy was used.” The teacher could then ask the students to brainstorm with peers to build on the provided example to offer a more detailed expression of their understanding. By sharing ideas first with group mates then with the class, all students have the opportunity to improve their conceptual understanding and expression of scientific ideas.

Several factors must occur in order for teachers to serve as facilitators of meaningful discussions. First, teachers must be knowledgeable about the subject matter. Second, teachers must create an environment that is free of threat of embarrassment from or bullying by classmates and that encourages students to share their ideas without penalty. Finally, students must trust the teacher to provide them with experiences that will help improve their conceptual understanding.

The students in the study were extremely verbal and readily expressed themselves on any number of topics. The researcher was surprised to see the lack of confidence when students discussed their science learning with peers. The force and motion concept was not new to these students. It had been discussed early in the school
year and the researcher hoped some of that conceptual learning would have been retained and expressed in dialogs pertaining to each inquiry. This was not the case. Students took key words from the focus question and occasionally used the word or concept in their dialog, but the understanding was superficial. Students inserted the vocabulary, most times correctly, but were unable to offer deeper explanations to classmates on what the concept incorporated. For example, in the Penny Push inquiry, the concepts of potential and kinetic energy were not addressed in any focus group discourse. One group did recall a prior teacher demonstration of momentum using Newton’s Cradle and tried to incorporate that experience into the Penny Push inquiry.

Inquiry three, the halfway point of the study, continued to build on concepts introduced in the first two lessons. At this point students had been working with the concepts of force, mass, potential and kinetic energy and inertia. Those same principles were applied in the Losing Your Marbles inquiry where students were asked to examine the motion of objects. Students in all focus groups were able to express to each other that a ball, when released from being spun beneath a bowl, will travel on a straight line which is consistent with NSES. However, the concepts of force, inertia, or even energy, did not emerge in any discourse based on what the students’ expected to observe or what they actually observed during the lesson, which is contrary to expectations outlined in NGSSS. Although the ideas expressed hint at conceptual understanding, the clear, precise explanation of understanding based on observations and supported with data based evidence was missing.

Several interview questions directly asked the students about the discourse that took place within the small group. Very little data were obtained from these interview
questions. This was a surprise to the researcher. Generally, the students at Dolphin Elementary relished the idea of being able to speak with a teacher on a one-to-one basis and had a tendency to talk in great length about any of a variety of topics. While students may have enjoyed the attention of one-to-one interaction with a teacher, that interaction did not yield the detailed results the researcher expected.

One reason the interviews may have yielded such limited data may be the students were nervous around the researcher. Another reason may be the students had never been asked to participate in an interview before and were unaccustomed to reflecting about their learning and experiences in this manner. Yet another reason may be students did not yet possess the ability to process information metacognitively. Despite the somewhat limited data gathered during students interviews, the interviews were a useful tool for learning about the students’ perception of the science lessons.

Teachers might be able to incorporate informal interviews to their classrooms as a tool to improve student’s conceptual learning. While not plausible for an everyday assessment, teachers may be able to interview students to gauge the progression of their learning about a given science topic. Additionally, during these interviews, teachers may be able to guide students to increase their metacognitive capabilities by asking probing questions and working with students to articulate their thoughts more elaborately.

Throughout the study, students used three types of discourse to communicate with each other in small groups, benevolent, assertive, and side talk. Throughout all discourses, students’ conceptual learning was hidden beneath the simplest expression of science concepts. Evidence of cognitive processes such as explaining, elaborating, and
clarifying leading to students’ conceptual learning was left to inferences and deductions made by the classroom teacher and researcher using the NSES and NGSSS as guidelines.

**Group dynamics and expression of conceptual understanding.** Beginning with the first inquiry, students worked in small groups and used all three discourse types to express themselves and their learning. However, students did not apply scientific vocabulary or principles into the conservations. For example, in the Penny Push inquiry students shared ideas within the small group, “The penny will force all the other pennies to move a little bit.” Others showed support, “Yeah” or “OK”. No one expanded the initial idea to develop it into a well thought out science concept, such as the force of the penny colliding with a row of pennies showed energy being transferred from one penny to the next by each one moving a little bit.

In other inquiries, such as Motion Notion, benevolent and assertive discourses were intermingled within the same group. The students who assumed self-selected jobs or leadership roles within the group regularly engaged in benevolent discourse as they were planning and building the maze. The discourse used was to encourage others to continue to build upon a particular procedural idea, “That’s a cool idea,” or “Yeah, I like that.” Yamaguchi and Maehr conducted a study of group dynamics and the role of emergent leaders using 249 fourth and fifth grade students from three elementary schools over a one-year period. Findings indicated students, both male and female, believed the when a leader emerged within the group, the group had greater group cohesion and regulation than when no leader was present (2004).

Contrary to the findings of Yamaguchi and Maehr (2004), students in this study were not uniformly satisfied with the leaders of the group or their role within the group.
Unsatisfied students tried and assert themselves into the planning and building, “This should go there to make it harder.” Some groups accepted these suggestions and others ignored the assertion. Again, data showed through the simple exchange of ideas students understood inertia would impact the movement of the marble along the path of the maze, but students never articulated the specific science concept, contrary to the guidelines of both NSES and NGSSS.

When students shared or debated the planning of the maze, they knew they would have to move a marble along the path without picking the maze up from the table. With that in mind they expressed ideas on paths they felt would make the maze hard or easy. However, they never addressed the concepts of paths of motion or inertia in any type of discourse. This lack of concrete expression of scientific conceptual learning may be attributed to the students’ age, make-up of the group, or to the fact they have had little practice in articulating ideas based on evidence observed in the lesson.

Using Vygotsky’s (1978) framework that students can negotiate meaning by alternating roles as expert and novice within a learning experience, the researcher had hoped through the use of assertive language students would be able to challenge one another’s thinking and press each other to refer to data and prior understanding of science conceptual learning to deepen their understanding of the current science topic. This did not occur. Lack of using assertive discourse to gain conceptual understanding may be attributed to lack of understanding of how to assert their thoughts as suggested previously. The students in this study might have been too young to fully understand how to balance the emotional aspect of wanting or believing something with supporting that concept with facts. The articulation of assertive discourse may be dependent on the
group make up and the climate created by the students in the group. If there is an
environment of mutual respect students might be more willing to assert themselves and
perhaps the group could benefit from that sharing. Conversely, if students perceive
unequal distribution of power in the group, they may keep their ideas to themselves and
in turn lose an opportunity to improve their conceptual learning by talking with peers.

Leadership and conceptual learning in small groups. Similar to the findings of
Richmond and Striley (1996), student roles and leadership styles in the present study
influenced both discourse and actions within the small groups. Over a three-month
period Richmond and Striley observed and videotaped 24 tenth grade students as they
conducted four science investigations. Results indicated two dimensions were
intertwined in the development of students’ conceptual understanding: conceptual and
social. Conceptual dimension was characterized by the use of scientific problem solving
and scientific argument. Social dimension was characterized by students’ attitude about
their role within the group and attitude toward the task. The roles and leadership styles
within the group influenced the participation of students within that group and that
participation, or lack thereof, influenced the development of scientific argument and
ultimately scientific conceptual understanding (Richmond & Striley, 1996). In the
current study, students’ discourses were more focused on the social dimension, which
Gee classified as relationships (2005). While the social aspect, as evident in roles and
leadership positions within the group may have played a role in conceptual
understanding, the degree of influence is unknown.
Research Question 2

What is the nature of elementary students’ independent written discourse in science notebooks as related to conceptual learning? For this discussion the two parts of the science notebooks: data collection and Quick Write will be addressed separately. Results described in chapter 4 indicated the nature of students’ written discourse in science notebooks were classified on a scale of simple to complex understanding and sorted into three tiers: clear and concise expression of science concepts (Tier 1), partially expressed scientific concepts (Tier 2), and flawed or erroneous ideas (Tier 3).

Data collection section of notebooks and conceptual learning. Based on the thoroughness of notebook responses, use of vocabulary, and expression of science concepts according to NSES and NGSSS, the researcher understood students had a basic understanding of the force and motion concepts presented in the six inquiries. However, students lacked the ability to fully and completely express that understanding in terms of elaborate notebook entries based on observable claims and evidence gathered during the science lessons. This finding is consistent with the work of Baxter, Bass, and Glaser (2001) who collected data from three fifth-grade classrooms in two separate schools. Results from the study indicated most student notebooks contained a purpose that lacked an expression of conceptual understanding and data that included records of observations. Conclusions were mostly absent but when present contained single sentence summaries or definitions rather than analysis of data (2001).

In this study, students’ science notebooks contained evidence of the students’ awareness of the importance of using vocabulary in their work to show their conceptual learning. When vocabulary was used in any section it was simply listed. Students did not
explain the concept and tell how it was applied in the particular inquiry. This was disappointing to the researcher because the students had been exposed to these concepts earlier in the school year.

Over the course of this study, students regularly showed basic or partial understanding of science concepts in the data collection sections of their notebooks. The data collection portion of the notebook included several sections highlighted by Rivard to be beneficial to students’ learning: note taking in the data section, analyzing in the claims and evidence, and summarizing in the conclusions (2006). A majority of students used vocabulary from the focus question in their prediction of the inquiry. However, that prediction was never expanded. Students simply addressed the focus question in a simple statement and labeled that response a prediction with no scientific support. This was a disappointment given the suggestion that explaining scientific concepts aids students in deepening their understanding of that concept (Prain & Hand, 1996). Perhaps this lack of elaboration is a side effect of teachers focusing on standards and encouraging students to find the right answer in terms of formal assessments.

Aschbacher and Alonzo (2006) have suggested that because elementary students do not usually grasp a concept as soon as it is introduced, notebooks serve as a formative assessment that detail students’ progression of conceptual learning. While interesting, students in this study did not provide evidence of a gradual increase of conceptual understanding in their science notebooks as the lessons progressed. This lack of development of conceptual learning, as evident in science notebooks, may be attributed to the short time frame of the study. It may also be attributed to the fact neither teachers
nor students received any training in or feedback on how to effectively compose science notebook entries that serve as a foundation for conceptual learning to develop.

The claims and evidence section of the data collection portion of the notebooks showed a slight improvement in students’ expressions of understanding of science concepts. This portion of the notebook was set up modeling a t-chart where students wrote their claim on left and evidence of that claim on the right. The researcher provided thinking tools/sentence starters to each category to aid students in understanding how to use the claims and evidence. Claims were explained on every notebook page to mean “I think” and evidence was explained as “because”. Using these sentence starter guides may be one-reason students’ expressed their learning with a bit more detail than any other area of the data collection notebook.

While this section of the notebook contained the most evidence of students’ learning, there was great variety in the quality of that knowledge. That variety may be reliant on students’ individual development. Some students may not yet be developmentally able to reflect, review, and elaborate on the inquiry in a manner useful for revising and editing their original notebook entry (Klein, 2000).

**Quick write section of notebooks and conceptual learning.** Despite the limited detail in students’ science notebooks, students reported enjoying the Quick Write and explained that it was helpful to guide their understanding of science concepts. However, the data did not support this claim. Despite the researcher created notebook script where students were directed to include what they learned and how they felt about the science experience, only three students used the Quick Write to summarize and apply science concepts based on evidence from the lesson. All other students’ notebook entries, 83 out
of a total of 86 collected, used the Quick Write to express their feeling about their group, not their learning. These findings are in line with Mason (1998) and Rivard (2006) who suggested this type of expressive journaling shows less positive impact of conceptual learning than other types of notebook entries.

Although each science inquiry built on the previous, the science content within each inquiry varied slightly. The content and the tasks that supported the understanding of the content may have had an impact on students’ written discourse in science notebooks and ultimately their conceptual understanding. For example, both inquiries three and four, Losing Your Marbles and Hide and Seek Energy had the most examples of Tier-1 entries: clear and concise examples of conceptual learning. It is interesting to note, both inquiries had enough supplies and time for each student to have equal opportunities to participate in the experience, be it manipulating tools, measuring data, or comparing results with group mates. It is also interesting to note both inquiries also had high numbers of both benevolent and assertive discourses. It may be noteworthy to point out the necessity of equal opportunities for all to fully participate in science inquiries in order to improve science conceptual understanding.

In addition to equal opportunities, students must have a clear purpose in their writing. Writing in the notebook because the teacher told them to may not yield products that truly showcase the students’ conceptual understanding. Students must have a clear understanding of the purpose for the writing. Students’ perceptions of that writing, including their level of interest, level of difficulty, and importance of the task influence the effort students put toward completing the assignment (Brookhart & Bronowicz, 2003).
Research Question 3

What is the relationship between students' evidence of conceptual learning in small group discourse and their independent written evidence of conceptual learning? Results described in chapter 4 illustrated a slight relationship between the two main discourses present in both students’ written and oral discourse: benevolent and assertive. Using a combination of oral and written discourse helps students develop conceptual understanding (Yore, Bisanz, & Hand, 2003). Given the researcher’s classroom experience, these findings were not surprising. However the link, or lack thereof, to students’ conceptual learning was a surprise. The researcher expected to find students passionate about their scientific beliefs and show that passion by adamantly trying to convince classmates their idea was correct and ultimately persuading classmates to change their point of view of a given science concept, thus expressing their learning by clear cognitive processes such as explaining, elaborating, and clarifying ideas based on observable evidence and theories drawn from that evidence. That was not the case. Given the framework of socioconstructivism that indicates students’ conceptual learning may be improved by working and sharing ideas with others, this was a disappointing finding (Vygotsky, 1978; Scott, Asoko, & Leach, 2007).

Perhaps the limited link between oral and written discourse could be attributed to the different types of modalities present in oral and written discourse. Oral discourse is social and includes asking questions, explaining, and formulating ideas. Written discourse is personal and includes refinement and consolidation of new ideas and prior knowledge (Rivard & Straw, 2000). Given the students’ age, switching between both
modalities might have been too difficult for students to accurately express what they knew.

Berland and McNeil (2010) studied fifth, seventh, and twelfth grade students seeking evidence of their learning progression in both oral and written data regarding various science topics. Their findings suggested the role of the teacher is critical to establishing classroom norms that enhance science conceptual understanding. The role of the teacher needs to include creating science discourse norms guided by and revised with the teacher where students defend their scientific claims with evidence. A shift from seeking a correct claim about a science concept to supporting an idea based on observed evidence is critical to developing science conceptual learning. As students begin to understand and practice justifying their claims with scientific support the evidence of conceptual learning will also appear in written discourse. However, as Berland and McNeil suggest, without students understanding why they are providing a written response, written discourse will lag behind oral in terms of justifying claims and ideas because students do not see the purpose of the task (2010).

In addition to practice, Berland and McNeil (2010) suggest students’ age is directly related to students’ ability to develop and justify scientific claims both in oral and written discourse. Younger students will have greater difficulty formulating and aligning oral and written arguments, but with practice, they will be able to improve their conceptual understanding (Berland & McNeil, 2010). Results from the present study indicated students had a rudimentary understanding of linking oral and written discourse. Students reflected benevolent discourse in oral and written communications when there was general consensus within the group. This general consensus was discovered quickly
and reflected by all students agreeing to a particular topic and writing the same response in their science notebooks, but no in-depth, individual, additional explanations were offered in the notebooks.

Previously addressed group dynamics were also evident in the relationship between oral and written discourse. Students who were unsure of the scientific concept associated with the lesson remained quietly in the background and did not offer ideas. When the more confident classmates or those that assumed leadership roles presented ideas orally, those who were unsure wrote the concept presented by the classmate in their notebook along with the rest of the group. These findings suggest students may not yet be developmentally ready to engage in in-depth discussions about science learning, yet they recognize the importance of working collaboratively with peers to improve their conceptual understanding. In older students, the work of Syh-Jong suggests referring to written discourse helps the speaker articulate clearly and concisely while oral discourse helps students more accurately express topics that were implied in writing (2007). It was the hope of the researcher that the early exposure provided to elementary students in linking oral and written discourse will enable them to improve their science conceptual understanding as they continue their education.

Mistakes, misconceptions, and omissions of science concepts were present in both oral and written discourse, but were not prevalent. Interestingly, when these expressions occurred, they were not corrected either by the individual or anyone in the group in either oral or written discourse. No one in the group spoke up to correct mistakes, nor did students change notebook entries to reflect correct ideas of science concepts, even after teacher led discussions explaining the lesson and scientific concept.
As previously mentioned, the importance of adequate supplies and opportunities to completely participate in science inquiries should not go unnoticed. In order to have more opportunities to develop both oral and written discourse as a tool to enhance science conceptual learning, students must be able to practice this experience regularly. This involves a paradigm switch in the classroom from teacher-centered science experiences to student-centered learning opportunities. However, these opportunities must come with proper training for both students and teacher if the endeavor is to be successful.

**Role of the classroom teacher and students’ conceptual learning.** A classroom teacher that is effective, efficient, and hopefully passionate, about teaching and learning is essential for students to improve their conceptual understanding. While not a central focus of the current study, reflection on the results cannot be drawn without acknowledging the role of the teacher in all aspects of science content learning. In order to accurately instruct students, teachers must have three types of subject matter knowledge: content knowledge, pedagogical content knowledge, and curricular knowledge (Shulman, 1987). Content knowledge includes being aware of the frameworks of a subject and how new knowledge is generated in that subject. Pedagogical content knowledge includes the understanding of how to use a variety of teaching methods to address students’ understanding and preconceptions of a subject. Curricular knowledge includes understanding what instructional tools are available and should be used to teach a particular content (Shulman, 1987).

In the present study teachers’ knowledge; content, pedagogical, and curricular, may have influenced the nature of students’ oral and written discourse. Specially, if
teachers did not have the strategies to teach students on how to effectively communicate in small groups while expressing their understanding of a topic, students did not do it well. Based on observations, it would seem teachers did not take the time to express the importance of recording data, claims and evidence, and conclusions, in science notebooks and consequently, students did not place value on the task and did not completely apply themselves to it. In this study, it seemed apparent when the teacher did not provide feedback to students on oral and written discourse, the students did not understand if and how they advanced toward the goal of greater scientific conceptual understanding. In order to effectively reach students and guide them to use oral and written discourse to enhance their conceptual understanding, teachers must have frequent and quality experiences with professional development and interactions with mentors.

**Research Question 4**

How does gender influence discourse during independent writing and group communication as related to conceptual learning of the science material? Results in chapter 4 indicated there was little influence of gender on students’ written and oral communication as related to science conceptual learning. This is contrary to the findings of Guzzetti and Williams (1996) who studied two high school physics classes over a seventh month period. Findings from the study indicated boys were dominant over girls in oral discourse during small group interactions. Guzzetti and Williams also found a difference in oral discourse that was not evident in the present study: boys argued to refute others’ ideas whereas girls posed their contrary ideas in the form of questions. The differences between the two studies may be attributed to age of participants or understanding of science concepts.
Greenfield (1997) conducted a mixed methods study for one semester of students in grades K-12 to examine the role of gender in students’ attitude toward and participation in science. Results had two similarities with the present study: 1) gender did not impact students’ attitude or participation, 2) girls were just as likely as boys to participate in science lessons.

Within focus groups of this study, when either boys or girls expressed a science concept their group mates believed was correct the group adopted that concept and used it as their own. That is, one student offered an idea, such as “I think inertia effected the balls because it kept them moving in a straight line across the table” and that same concept appeared in the claims and evidence section of the notebooks of all members of that group.

In this study, students used three types of oral discourse: benevolent, assertive, and side talk. Girls in this study were very active and articulated their desire to be completely involved in the inquiry from set-up to conclusion. These results are similar to the findings of Greenfield who reported girls are as equally likely as boys to set-up, conduct experiments, observe, and record data (1997). Greenfield further suggested results indicated girls would not relinquish supplies or their role as an active participant in science experiments to boys. Girls who participated in the current study were observed setting up pan balances, organizing and disturbing materials to all group mates, taking the lead in conducting inquiries, and cleaning up when activities were complete. These findings are contrary to the results Mewborn reported where girls preferred to act in secretarial roles that could inhibit conceptual learning (1999).
Tolmie and Howe (1993) conducted a study of 82 students between the ages of 12 and 15 as they participated in force and motion lessons. They noted small groups consisting only of girls tended to seek common ideas while predicting and explaining within those groups, while boys tended to argue over these same points. The findings further indicated in mixed gender groups, such as in the present study, small groups tended to avoid conflict and seek ways to find common patterns in contributions.

Findings indicated more important than the gender make-up of the group were the students’ ideas about particular science concepts. Groups that had students with varying ideas and theories on scientific concepts showed the most improvement in conceptual understanding. In the present study, students did not voice dissimilar ideas or theories, and according the research of Tolmie and Howe that would have been one way to use the small group experience to improve conceptual learning (1993). Although based on work with slightly older students, these finding are similar to the results in the present study which found benevolent discourse was the most common and when ideas were suggested within groups, by boys or girls, the group accepted and recorded those ideas in the science notebook as their own.

Implications for Elementary Classrooms

Based on the outcome of this study, several implications for practice in the elementary classroom are offered. To improve students’ conceptual understanding of science, teachers must become more aware of their practices and seek to improve instruction and student learning by attending professional development opportunities focused on best practices in science education that offer suggestions on how to scaffold students’ experiences to improve their science comprehension. As outlined by
Zemelman, Daniels, and Hyde, these best practices include, but are not limited to being: student-centered, experiential, authentic, expressive, reflective, and social (1998). Within this teacher training, essential components of effective science discourse must be present such as communicating ideas to peers and reasoning to support expressed ideas. When teachers understand how to guide students to effectively communicate with peers, students may more capable in taking part in small group experiences.

Another implication for practice is the development of generating and responding to testable science content-based questions. Based on this study, students had no difficulty asking simple, concrete questions to peers such as, “Where does this go?”, but these questions did little to advance conceptual understanding. To become more deeply involved in the inquiry process, and improve science learning, students must be able to generate and respond to well thought out scientifically based questions pertaining to particular topics.

Teachers may be able to expand their assessment of students’ conceptual understanding by adding interviewing to their formative assessment routine. Taking several minutes when students are independently completing the conclusions in their science notebooks, teachers could individually ask a few key questions to students to assess their progress. Benefits of adding interviews to formative assessment include immediate feedback for both teacher and student on learning, and the opportunity to expand and challenge scientific awareness to aid students in developing a deep understanding of science concepts. However, due to limitations of NCLB legislation that stresses the rote recall of knowledge, interviewing is not currently a frequently used strategy in elementary classrooms.
NCLB was created in 2001 to ensure all students were able to advance their understanding of core subject matter (U.S. Department of Education, 2009). While the interpretation and enactment of the legislature vary by state, the state of Florida utilizes the Florida Comprehensive Assessment Test (FCAT) as a tool to assess student learning (FL DOE, 2010). Students’ scores are used to document if a school has made Adequate Yearly Progress (AYP) in student learning as outlined by NCLB. The A+ Plan gives financial incentives to schools in Florida that are classified as A+ and meet AYP (FL DOE, 2010). Consequently, teachers and administrators may be pressured to constantly increase test scores. Unfortunately, this pressure may lead some schools to deviate from best practices and stress memorization of facts and teaching of test-taking strategies. This is contrary to the findings of this study. Students need to engage with each other and teachers to apply and improve oral and written communication so exchanges will lead to development of greater conceptual learning. Students and teachers could gain valuable learning experiences that may enhance conceptual learning if provided the opportunity to share and debate scientific ideas. Students need to practice composing and editing written discourse in science notebooks with feedback and input from the teacher to improve their conceptual understanding. With ongoing stress on AYP and school grades, the valuable exchanges between students and peers and students and teacher may be lost.

The final implication for elementary classrooms based on this study is the need to examine education policy, such as NCLB and how the implications of that policy impact students’ conceptual learning. While NCLB emphasizes the need for assessment of factual recall of content, it does not address the multiple layers of conceptual
understanding students must obtain to develop a deep conceptual awareness. If teachers are compelled to alter best practices teaching in favor of covering more content in a breadth rather than depth of learning approach, students will have fewer opportunities to engage each other in oral discourse, to reflect on learning in written discourse, and have less personal interaction with and guidance from the teacher. Ultimately, students’ conceptual understanding will be impeded.

Professional development experiences that enable teachers to improve their pedagogical content knowledge, subject matter knowledge, awareness of best practices in science education, and assessment of student learning are key to improving students’ science conceptual learning. However, infrequent or irregular workshops are not effective at promoting long-term teacher improvements in these areas. Rather, teachers need to meet regularly to collaborate and discuss issues, have time to participate in learning opportunities that remind the teacher of the student’s perspective, and reflect on those experiences (Zemelman, Daniels, & Hyde, 1998). Creating cohorts or learning communities for teachers could meet these goals.

Weekly professional development meetings with a long-term plan for improving both teaching practices and students’ conceptual understanding should be scheduled in all schools. Professional development seminars must extend teachers’ current subject knowledge in order to more adequately prepare teacher to be effective classroom instructors. Specifically, teachers’ need to gain experience in all areas of science education, including physics, chemistry, and biology to meet the needs of their students. To facilitate this process, stakeholders such as policy makers, administrators, and teachers must take an active role in supporting the experience. Policy makers could
create a mandate to allow time for teachers to meet. Policy makers could also draft incentives for teachers participating in university courses in science. Incentives may be either financial or in the form of comp time with substitute coverage so teachers are enabled to observe and reflect on their students’ learning and bring those experiences to the university classroom to be shared and debriefed with colleagues. Administrators could support the effort of the teachers by inquiring about their experiences and offering support for the additional work teachers are undertaking. Finally, teachers must enter the experience with a positive attitude and believe the experience will benefit both themselves and their students. Teachers must believe the role of educator is constantly changing and they must be willing to learn about new ways to meet the needs of their students.

Within the weekly professional development meetings, the agenda could begin with a focus of curriculum knowledge including recent changes in state standards. The program could then move to a review of best practices and knowledge of teaching, specifically Pedagogical Content Knowledge (Shulman, 1987). The experience could culminate with hands-on experiences in inquiry-based teaching with roles alternating from teacher to student to gain a greater understanding of the teaching and learning process.

Throughout the professional development opportunities, teachers will create communities of learners. Those communities allow members to share, reflect, and learn from one another. The exchange of ideas and the revolving roles of those in the group from expert to learner may help teachers reflect on their own practice and lead to
improvements in their classroom with the manner in which they create learning opportunities and engage their students.

Another aspect of professional development is having opportunities to engage with expert teachers. Teachers should have access to those with greater knowledge and more expertise such as National Board Certified (NBC) teachers. Teachers that have obtained National Board Certification are found to exhibit five core propositions: (a) commitment to students and their learning, (b) knowledge of subjects taught and how to teach those subjects, (c) responsibility for managing and monitoring student learning, (d) think systematically and learn from their practice, (e) members of learning communities (National Board for Professional Teaching Standards, 2010). These qualifications make NBC teachers excellent mentors for those in the process of modifying and improving their teaching. During the process, NBC teachers will also benefit from the experience by working with others to debate, share, and reflect on classroom practices as part of a learning community.

**Recommendations for Further Research**

To better understand the conceptual learning of fifth grade students as related to oral and written discourse, research into the importance and effectiveness of teachers’ modeling of detailed scientific oral discourse within small groups is recommended. Using comparison groups of teachers with and without training in formulating and guiding small groups to generate oral discourse that yield higher order thinking about and understanding of scientific concepts is warranted. Researching the nature of scripted and nonscripted science inquiries, in relation to the students’ conceptual understanding
and teachers’ content knowledge would provide details about the interactions of teachers’ and students’ scientific knowledge.

The manner in which students conduct and learn from written discourse also requires more research at the upper elementary level. Examining the role of the teacher in this aspect of science learning is critical. Students at this age need to be properly guided by their teacher on how and why they are writing in science. Without a basic understanding of the task at hand, students are less likely to take ownership of their learning. However, teachers must have the scientific background and confidence that allow them to guide students to think deeply about science concepts. Future research examining the amount and quality of science education teachers receive in their preservice training could provide evidence of how to improve teachers’ engagement with written discourse and how to improve their students’ conceptual learning based on that discourse.

The role of the teacher, within the context of science instructor, should be studied further. First, an examination into the amount of content knowledge classroom teachers’ possess in physical science and how that knowledge relates to their confidence in instructing students. Stemming from that, a deeper look into how actively teachers engage and guide students during oral and written discourse in science inquires would provide a greater understanding of the relationship between teacher knowledge and involvement with student knowledge and conceptual understanding.

Additional research into the connection and relationship between oral and written discourse of upper elementary students is needed. Further research should focus on one aspect of this connection and delve deeply into that area. Suggestions for specific
additional research on the connections between oral and written discourse include: impact of social connections on written and oral discourse and how those connections influence conceptual learning; influence of instruction styles, such as inquiry or text-based, and the impact of gender on small group oral and written discourse and how gender impacts the conceptual understanding of those within the small group.

This study did not find one aspect of gender greatly impacted either oral or written discourse. With the great variance of gender identity and roles more research into boys’ and girls’ scientific conceptual understanding at the upper elementary level is needed. For example, examining the role of gender and types of questions and responses uttered by students or examining the quality and type of written responses in notebooks or concept maps with supporting scientific claims with evidence from lessons may provide greater detail into the conceptual development of fifth grade students.

It is clear from this study there is a great deal to discover about the science conceptual understanding of upper elementary school students. Within the frame of science conceptual understanding more research into the communication between students and the thoughts behind that communication, both oral and written, must continuously be researched to provide elementary school students a strong basic understanding of scientific concepts. Teachers and researchers collaborating will be able to provide students the framework of scientific thinking that will enable them to develop and expand their conceptual understanding as they progress through their schooling.
APPENDIX A

FLORIDA ATLANTIC UNIVERSITY INSTITUTION

REVIEW BOARD APPROVAL

DATE: February 12, 2010
TO: Gail Burnaford
FROM: Florida Atlantic University IRB

PROTOCOL #: H10-01
PROTOCOL TITLE: [143206-2] The Nature of Elementary Students’ Science Discourse and Conceptual Learning

SUBMISSION TYPE: Response/Follow-Up
ACTION: APPROVED

APPROVAL DATE: February 12, 2010
EXPIRATION DATE: February 13, 2011

REVIEW TYPE: Expedited Review
REVIEW CATEGORY: Expedited review category B7

Thank you for your submission of Response/Follow-Up materials for this research study. The Florida Atlantic University IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

- It is important that you use the approved, stamped consent documents or procedures included with this letter.
- Please note that any revision to previously approved materials or procedures must be approved by this office prior to initiation. Please use the appropriate amendment forms for this procedure.
- All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All FDA and sponsor reporting requirements should also be followed, if applicable.
- Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.
- Please note that all research records must be retained for a minimum of three years.
- This approval is valid for one year. A Continuing Review form will be required prior to the expiration date if this project will continue beyond one year.

If you have any questions or comments about this correspondence, please contact Elisa Gaucher at:

Institutional Review Board
Research Integrity/Division of Research
Florida Atlantic University

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APPENDIX B

BROWARD COUNTY INSTRUCTIONAL REVIEW BOARD APPROVAL

THE SCHOOL BOARD OF BROWARD COUNTY, FLORIDA
RESEARCH SERVICES
600 SOUTHEAST THIRD AVENUE • FORT LAUDERDALE, FLORIDA 33301 3125 • TEL 754-321-2500 • FAX 754-321-2722
MARIA R. LIGAS, Ph.D.
Institutional Review Board (IRB) Chair
marialigas@browardschools.com

May 5, 2010

Melissa Parks
9661 Santa Rosa Drive
Tamarac, FL 33321

Dear Ms. Parks:

Thank you for submitting your proposal #589 — The Nature of Elementary Students’ Science Discourse and Conceptual Learning, for consideration by the Broward County Public Schools (BCPS). Staff has reviewed your research proposal and approval has been granted for you to contact Kenneth King, Principal at Heron Heights Elementary School, to request his participation. This approval means that we have found your proposed research methods to be compatible with a public school setting and your research questions of interest to the school District.

Due to one of the science lessons involving eggs, reviewers voiced concern with Safety procedures. Please make sure the Safety Policies and Procedures are followed specifically. Safety goggles must be worn by students and teachers for the activities described in this project.

Based on the information you have supplied, your approval to conduct research will expire on Thursday, May 5, 2011. If you are unable to complete your research by the expiration date, you must submit an Annual Report/Request for Renewal, (http://www.broward.k12.fl.us/research_evaluation/IRB.Pdf), to the Research Services Department four weeks prior to the expiration. If a renewal is granted, a Renewal Letter and Memo will be issued.

Implementing your research, however, is a decision to be reached by the affected school-based staff on a strictly voluntary basis. To assist school-based staff in their decision, please outline the operational steps to be performed by staff at their school. Based upon this information, each school-based staff would then be asked to make a decision to participate or not and inform you or the requesting research parties of their decision at the time of your request. You must also share this Approval Letter signed by the IRB Chair and provide a copy of the attached Approval Memorandum which has been initialed by the Area Superintendent and the IRB Chair. School-based staff have been instructed not to cooperate unless you provide both pieces of Approval Documentation.

Pursuant to your proposal, the anticipated date for submitting an electronic copy of the research findings is Thursday, May 5, 2011. If additional assistance is needed from our staff, please contact me at 754-321-2500.

Sincerely,

Maria R. Ligas, Ph.D.

MRL/MAL:bt
Attachment
APPENDIX C

PRINCIPAL APPROVAL

THE SCHOOL BOARD OF BROWARD COUNTY, FLORIDA

Heron Heights Elementary
Kenneth J. King, Principal
13010 Nob Hill Road
Parkland, Florida 33076
(754) 322-9150 – Facsimile (754) 322-9190

February 16, 2010

To Whom It May Concern:

Melissa Parks is a fifth grade teacher at Heron Heights Elementary. I support her participation in the research study, The Nature of Elementary Students’ Science Discourse and Conceptual Learning, which will be conducted by Ms. Parks as a dissertation requirement for Florida Atlantic University.

The focus of this study is to investigate the written and oral discourse as it relates to the conceptual learning of grade five students within one science unit. Ms. Parks will obtain permission from students’ parents and assent from students prior to completing the study. Students that do not participate in the study will not be negatively affected.

I understand if I have any questions about this research study I can, at any time, direct those questions to Ms. Parks, the principal investigator, at (754) 322-9150 or her faculty advisory, Dr. Gail Burnaford at (561) 297-2305. The Florida Atlantic University Division of Research may be contacted at (561) 297-0777.

Sincerely,

Kenneth King
Principal
Heron Heights Elementary

Transforming Education: One Student at A Time
Broward County Public Schools Is An Equal Opportunity/Equal Access Employer
APPENDIX D

PARENTAL CONSENT

PARENTAL CONSENT FORM

1) **Title of Research Study:** The nature of elementary students’ science discourse and conceptual learning

2) **Investigator(s):** Responsible Project Investigator: Gail Burnaford and Co-Investigator: Melissa Parks

3) **Purpose:** The purpose of this research study is investigate the written and oral discourse as it relates to the conceptual learning of grade five students within one science unit. Patterns or relationships, if any, that exist between the written and oral discourse with respect to students’ science conceptual learning will be examined.

4) **Procedures:**
As part of the normal school curriculum, each of the three fifth grade classes will complete six science inquiry-based lessons on force and motion with their regular classroom teacher (attached). The classroom teacher will divide your child’s class into student groups of 4-5 depending on class size and existing classroom procedures for using the science lab. Using existing numbers of the tables in the science lab, all table numbers will be entered in a bag and one table number will randomly be drawn. Based on that number, all students seated at the table, will be targeted as the focus for all six inquiries. Your child will complete six inquiry-based science force and motion lessons as part of the normal school curriculum. During each of the inquiries the selected group of students will have a voice recorder at the table to record group discourse. The researcher will observe no fewer than two science inquiries per class and no more than six inquiries per class during the course of the study. Observation protocol is attached. After each lesson, all students in the selected group will be asked to submit their science notebook to the researcher. The notebook template is attached. The notebook entries will be copied and the original notebooks returned to the students within 24 hours. After the first and sixth lesson, the same 12-15 randomly selected students will be asked to participate in a scripted ten-question interview about the science lesson. Interviews will be voice recorded. Interview protocol is attached

5) **Risks:**
Minimal risk is anticipated for your child. Your child will complete six science lessons that are part of the normal fifth grade curriculum. The risks involved with participation in this study are no more than your child would experience in regular daily activities. There are no penalties or rewards for participation. Your child’s grades will not be affected in any way by participation or lack of participation in this study.

6) **Benefits:**
Potential benefits that your child may attain from participation in this research study include the satisfaction of knowing that they have contributed to a better understanding of science conceptual learning of elementary students. Teachers may learn of ways to improve their educational practice by increasing their understanding of the connections between oral and written discourse and students’ science conceptual learning. Your child may better understand the importance of discourse, oral and written, and increase their personal understanding of science conceptual learning.

7) **Data Collection & Storage:**
All classroom teachers will be given randomly selected pseudonyms. All student participants will be given randomly selected gender-based pseudonyms. All observation notes, voice recordings, and interviews will be kept in a locked file cabinet in the office of the researcher. Only the researchers will have access to the file cabinet unless required by law or requested by a parent of a student participating in the study. All data will be destroyed one year after the completion of the study or no later than March 31, 2011.

8) **Contact Information:**
For related problems or questions regarding your rights as a research subject, contact the Florida Atlantic University Division of Research at (561) 297-0777. For other questions about the study, you should call the co-investigator, Melissa Parks at (754) 322-9150 or her faculty advisory and responsible project Investigator, Dr. Gail Burnaford at (561) 297-2305.

Consent continues on next page.

Parent/Guardian Initials: __________________________

FAU
Institutional Review Board

Approved on: 2/12/2010
Expires on: 2/11/2011

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9) **Consent Statement:**

*I have read, or had read to me, the information describing this study. All of my questions have been answered to my satisfaction. I allow my child *(first name)* ____________ *(last name)* ____________ to take part in this study. My child can stop participating at any time without giving any reason and without penalty. I can ask to have the information related to my child returned to me, removed from the research records, or destroyed. I have received a copy of this consent form.

My child may ____ may not ____ be audiotaped.

Signature of Parent or Guardian: ____________________________  Date: __________

Printed Name of Parent: ____________________________  Date: __________

Signature of Investigator: ____________________________  Date: __________
APPENDIX E

CHILD ASSENT

CHILD ASSENT

The Nature of Elementary Students' Science Discourse and Conceptual Learning

My name is Ms. Parks and I am a student at Florida Atlantic University. I am working on a research project about the way students talk to each other and how they write in their notebooks during science lessons. I hope this project will help me understand how fifth graders learn science skills.

You have been asked to participate in my project because your science table number was chosen when I pulled it from a bag filled with all the science table numbers. You can choose to participate or not participate in this project. If you decide to participate, you will be asked to complete six science lessons during your normal science class taught by your normal teacher. You will also be asked to give me your science notebook after each lesson. I will photocopy your notebook and give it back to you the next day. For certain parts of my project I will use a voice recorder. The voice recordings will happen during your science lessons and during the interviews. After the first and last lesson you will be asked to answer ten interview questions about the science lesson. You will be asked about what your group talked about in the science lesson. You will also be asked how you used your science notebook in the lesson. You will not get any reward for working with me and you will not be punished if you choose not to participate. This project will take place in the science lab at school, during the normal school day. Each science lesson should take about 50 minutes to complete. Each interview should take 10 minutes to complete.

You do not have to be in this project if you don’t want to. You can quit the project at any time. During the interview, if you don’t like a question, you don’t have to answer it. If you ask, your answers will not be used in the project.

Other than the researcher, me, no one will know your answers, including your teacher, friends, or classmates. If you have any questions, just ask me. I hope that you will learn more about science and about how you learn best, by participating in this project.

This research study has been explained to me and I agree to be in this study.

<table>
<thead>
<tr>
<th>Student's Signature for Assent</th>
<th>Date</th>
</tr>
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</table>

Check which applies (to be completed by person conducting assent discussion):

☐ The subject is capable of reading and understanding the assent form and has signed above as documentation of assent to take part in this study.

☐ The subject is not capable of reading the assent form, however, the information was explained verbally to the subject who signed above to acknowledge the verbal explanation and his/her assent to take part in this study.

Name of Person Obtaining Assent (Print)

<table>
<thead>
<tr>
<th>Signature of Person Obtaining Assent</th>
<th>Date</th>
</tr>
</thead>
</table>

Institutional Review Board

FAU

Approved on: 2/12/2010
Expires on: 2/11/2011
1) **Title of Research Study:** The nature of elementary students’ science discourse and conceptual learning

2) **Investigator:** Responsible Project Investigator: Gail Burnaford; Co-Investigator: Melissa Parks

3) **Purpose:** The purpose of this research study is investigate the written and oral discourse as it relates to the conceptual learning of grade five students within one science unit. Patterns or relationships, if any, that exist between the written and oral discourse with respect to students’ science conceptual learning will be examined.

4) **Procedures:**
Participation in this study will require you to teach six science lessons during the normal school day. Each science lesson will take approximately 50 minutes. Lessons will be taught over a six-week period. Each classroom teacher will select the day and time within the normal school day to teach the lesson. The classroom teacher will divide the class into groups of 4-5 students depending on existing classroom procedures. The classroom teacher is not the focus of this study, so a scripted inquiry lesson plan, which is the typical format used, will be provided for each of the six lessons (attached). The researcher will observe no fewer than two science inquiries per class and no more than six inquiries per class during the course of the study. Observation protocol is attached.

5) **Risks:**
Minimal risk is anticipated for the participants. Students will complete science lessons that are part of the normal fifth grade curriculum. The risks involved with participation in this study are no more than one would experience in regular daily activities. There are no penalties or rewards for participation. Students’ grades will not be affected in any way by participation or lack of participation in this study, and this is not related to teacher evaluations.

6) **Benefits:**
Potential benefits that you and your students may attain from participation in this research study include the satisfaction of knowing that you have contributed to a better understanding of science conceptual learning of elementary students. Teachers may learn how to improve their educational practice by increasing their understanding of the connections between oral and written discourse and students’ science conceptual learning. Students may understand the importance of discourse, oral and written, and their personal understanding of science conceptual learning.

7) **Data Collection & Storage:**
All classroom teachers will be given randomly selected pseudonyms. All student participants will be given randomly selected gender-based pseudonyms. All observation notes, voice recordings, and interviews will be kept in a secure electronic file and in a locked file cabinet in the office of the researcher. Only the researchers will have access to the file cabinet unless required by law or requested by a parent of a student participating in the study. All data will be destroyed one year after the completion of the study, or no later than March 31, 2011.

8) **Contact Information:**
*For related problems or questions regarding your rights as a research subject, contact the Florida Atlantic University Division of Research at (561) 297-0777. For other questions about the study, you should call the co-investigator, Melissa Parks at (754) 322-9150 or her faculty advisory and responsible project investigator, Dr. Gail Burnaford at (561) 297-2305.

9) **Consent Statement:**
*I have read or had read to me the preceding information describing this study. All my questions have been answered to my satisfaction. I am 18 years of age or older and freely consent to participate. I understand that I am free to withdraw from the study at any time without penalty. I have received a copy of this consent form. I agree _____ I do not agree ____ to be audiotaped during the interview.*

Signature of Participant: ___________________________ Date: __________________________
Signature of Investigator: ___________________________ Date: __________________________
APPENDIX G

PENNY PUSH

BENCHMARKS and TASKS

SC.B.1.2.1 The student knows how to trace the flow of energy in a system (e.g., as in an ecosystem).

SC.B.1.2.4 The student knows the many ways in which energy can be transformed from one type to another.

SC.C.2.2.2 The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

SC.C.2.2.4 The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object
  • The student identifies force as any push or pull (e.g., gravity, electricity and magnetism) that causes objects to change their state of motion. The greater the force is, the greater the change in motion.
  • The student describes the motion of an object by its position, direction, and speed.
  • The student traces the flow of energy as it is converted from one form to another (e.g., potential to kinetic) through a system.

KEY QUESTION

How is energy transformed from one type to another?

BACKGROUND INFORMATION

An object is in its equilibrium position when it is sitting still (no outside force is acting on it) and gravity holds it in place. The object has potential energy (stored energy). If two objects collide, momentum is transferred between them. When one moving object strikes a stationary object, the first moving object transfers some of its forward motion of energy, or momentum, to the stationary object, which is set in motion. The momentum can pass from one object to another and even to a third object. The moving object has kinetic energy (energy of motion).
MATERIALS

Teacher

Per pair of students

Dominos

10 pennies
1 quarter
1 dime
1 nickel
variety of coins

ENGAGE

1. Create a straight-line path of standing dominos. Make sure each domino is no more than 1½ inches from the next domino.
2. Ask students to predict what will happen when you push the domino at one end of the path.

EXPLORE

Student Directions:

1. Arrange nine pennies in a row on a desk. Make sure each penny is touching the one next to it.
2. Place another (tenth) penny about 12 cm from one end of the row. Give that penny a quick push so that it slides into the ninth penny in the row. What happened?
3. Rearrange the pennies. Try pushing the tenth penny harder. What happened?
4. Rearrange the pennies. Now push the tenth penny more gently. What happened?
5. Place eight pennies in a row so that each penny is touching the one next to it.
6. Place the remaining two pennies about 12 cm from the back end of the row.
7. Give the two pennies a quick push so that they both slide into the back end of the row. What happened?
8. Use a quarter as the knocking coin. What happened?
9. Use a dime as the knocking coin. What happened?

EXPLAIN

1. Force is any push or pull that causes objects to change their state of motion. What force caused the pennies to move? (The force was generated by the tenth penny pushing the ninth penny, the ninth pushing the eighth, and so on. Finally, when the pushing force was passed on to the penny at the far end of the row, that penny moved away from the others. The force of the knocker transferred all of its momentum to the row of pennies, setting them in motion. Momentum is the forward motion of energy.)
2. What happened when you pushed the tenth penny into the other pennies harder? (The penny on the far end moved away from the group.)
3. What happened when you pushed the tenth penny into the other pennies more gently? (The penny on the far end still moved, but not as far.)
4. What happened when two pennies were pushed into the other pennies? (Two pennies from the far end moved away from the group.)
5. What happened when a quarter was used as the knocking coin? (At least three pennies on the far end moved away from the group.)
6. What happened when a dime was used as the knocking coin? (One penny from the far end moved away from the group.)
7. What happened when a nickel was used as the knocking coin? (Two or three pennies on the far end moved away from the group.)
8. Was the force of the knocker a push or a pull? (a push)
9. Was the push of the knocker the only force acting on the pennies? (No, more than one force can, and usually does, act on an object at the same time.)
10. When did an energy transformation occur? (The pennies had potential energy while they were at rest. If two objects collide, momentum is transferred between them. When one moving object strikes a stationary object, the first moving object transfers some of its energy, or momentum, to the stationary object, which is then set in motion. That moving object has kinetic energy. Potential energy was converted to kinetic energy when the knocker hit the pennies and they began to move.)

EXTEND/APPLY

Encourage students to design another experiment, using different sizes of coins in a row and a different size coin as a knocker.

EXTENSION

Try the same investigation on different surfaces.
APPENDIX H

MOTION NOTION

BENCHMARKS and TASKS

SC.C.2.2.2 The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

SC.C.2.2.4 The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object.

- The student identifies force as any push or pull (e.g., gravity, electricity, magnetism) that causes objects to change their state of motion. The greater the force is, the greater the change in motion.
- The student describes the motion of an object by its position, direction, and speed.
- The student traces the flow of energy as it is converted from one form to another (e.g., potential to kinetic) through a system.
- The student demonstrates how inertia (an object’s tendency to resist a change in motion), gravity, friction, and mass affect motion.

KEY QUESTION

What is inertia and how does inertia affect the movement of objects?

BACKGROUND INFORMATION

The whole universe is in motion, from tiny particles to huge stars and planets. All objects tend to resist efforts to change their state of motion, whether they are actually moving or at rest. Newton’s First Law: Objects at rest tend to remain at rest. Objects in motion tend to stay in motion, traveling at a constant speed and in the same direction. The tendency of an object to remain at rest or to remain in motion is called inertia. However, all around us forces, pushes and/or pulls, act on objects, often making them change their state of motion.

Mechanical energy is the energy an object has because of its motion or position. There are two kinds of mechanical energy—kinetic and potential. Potential energy is energy an object has because of its position or shape. In this activity, the marbles have stored, or potential energy, because of their shape. When the marbles are set in motion, the
potential energy is transformed to kinetic energy, the energy an object has because it is moving. The greater the speed and the mass of an object, the greater its kinetic energy is.

MATERIALS

**Teacher**
- 1 embroidery hoop
- 5 marbles
- overhead projector

**Per group**
- 1 box lid (perhaps from a shoe box)
- 1 marble or metal nut
- glue bottle
- scissors
- pieces of heavy cardboard
- 1 sheet of paper
- 1 small paper cup
- paper clip

ENGAGE

1. Put the embroidery hoop on the overhead. Set marbles in the hoop and turn on the overhead light. Ask: Why aren’t the marbles moving? (The force of gravity is the dominant force pushing on them from above, and it is equal to the force of the projector pushing on them from below.) How could you make these marbles move? (Students may suggest you move the hoop. Do this, creating a push or a pull and causing the marbles to move.) How could you change the direction of the marbles’ movement? (Try various suggestions. You may change the direction of the push or pull, perhaps in a circular motion.)

2. Tell the students they are going to make a game which will depend on a basic principle of science, Newton’s First Law: Objects tend to resist efforts to change their state of motion whether they are actually moving or at rest. Let pupils try moving objects, such as a glue bottle or a marble, by moving a sheet of paper they have placed beneath the object. They will find that any object they test, once moving, tends to keep moving. When not moving, it tends to stay still unless a new force acts on it.

EXPLORE

1. Distribute a box lid, glue, scissors, thick cardboard, paper, and pencil to each group.
2. Tell students to design a maze inside the cover by gluing in narrow strips of thick cardboard. The maze may have any pattern from simple to complex. (Students may choose to design the pattern on paper first and then use the patterns as templates to cut the cardboard.) Be sure students designate a starting and finishing point in the maze.
3. Set the mazes aside to dry.
4. Now students are ready to play the game. Lay the box lid on a table and the marble or nut at the starting point. Each player, without lifting or tilting the lid, slides it this way and that way until the marble or nut reaches the finish. This can be done a couple of ways, both depending upon inertia. First, they may slide the lid to get the marble or nut moving, and then stop the cover abruptly, letting the marble or nut keep moving. Or they may slide the cover abruptly, letting the marble or nut stay still.

5. Students may keep records of how long it takes them to complete the track, beginning with the first attempt. A graph of successive times should show how much a player could improve his skills with practice.

**EXPLAIN**

1. Did the marble always go where you wanted it to go? Why?
2. Force is any push or pull that causes objects to change their state of motion. What forces caused the marble to move? (the forces of gravity and the push and pull on the lid by the student)
3. What force caused the marble to move in directions often opposite from the way you wanted it to move? (Inertia: Objects tend to keep doing whatever they have been doing, whether moving or standing still.)
4. When did an energy transformation occur? (The marbles had potential energy while they were at rest. Potential energy was converted to kinetic energy when the marbles started moving through the maze.)

**EXTEND/APPLY**

1. What does inertia have to do with people’s need to wear seatbelts? (When an auto starts to move, the people in it tend to stay still. When it stops suddenly, they tend to keep moving. That is why people need to wear seatbelts! They may be thrown out or hit their heads on the windshield because of inertia.)
2. What are some other ways inertia is evident in our lives?
3. Make a list of the ideas students suggest. Title the list Everyday Examples of Inertia.
4. Put a paper clip in a paper cup lying on its side. Move the cup quickly, open end first, and then stop it suddenly. What does the paper clip do? (The paper clip keeps on moving because objects in motion tend to stay in motion, traveling at a constant speed and in the same direction. An object’s tendency to resist a change in motion is called inertia.)

5. Put the paper clip back inside the cup, still resting on its side. Now, move the cup suddenly, bottom first. This time how does the paper clip react? (The paper clip stays just about where it was but falls onto the table as you slide the cup out from beneath it, because objects at rest tend to stay at rest.)

ASSESSMENT

In a science journal, have the students explain what this statement means: We must wear seatbelts because of inertia.
APPENDIX I

LOSING YOUR MARBLES

BENCHMARKS and TASKS

SC.C.2.2.2 The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

SC.C.2.2.4 The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object.
  • The student describes the motion of an object by its position, direction, and speed.
  • The student demonstrates how inertia (an object’s tendency to resist a change in motion), gravity, friction, and mass affect motion.

KEY QUESTION

What are some forces that can affect the motion of an object?

BACKGROUND INFORMATION

Newton’s First Law of Motion: An object at rest will stay at rest unless acted on by an unbalanced force. An object in motion will stay in motion at the same speed and in the same direction unless acted on by an unbalanced force. Newton’s First Law of Motion is also called the law of inertia. Inertia is an object’s tendency to resist a change in motion. All objects have inertia. The greater an object’s mass, the greater its inertia, and the larger the force needed to overcome the inertia.

Not all motion is linear (in a straight line). An object may oscillate, move back and forth, about a fixed point. It may also have circular motion caused by centripetal force, which keeps it moving in a circle instead of flying away.

MATERIALS

Per group
1 raw egg and 1 hard-boiled egg (see Teaching Tips)
1 circular bowl
1 Ping-Pong ball and/or other small balls
1 small rubber ball

TEACHING TIPS

1. Prepare one hard-boiled egg for each group ahead of time.
2. Have students wash their hands thoroughly after handling eggs.
3. Part 1 can be done as a teacher demonstration and this would require only two eggs – one raw and one hard-boiled.

ENGAGE

1. When a car turns a corner, what happens to the passengers? (They tend to sway or lean away from the curve.)
2. Why does this happen? (The passengers are experiencing inertia. The particles in their bodies want to keep going in a straight line. However, the car exerts centripetal force on the passengers; it forces them to turn the corner, changing their direction.)

EXPLORE and EXPLAIN (Part 1)

1. Give students one hard-boiled and one raw egg. Tell them the challenge is, without cracking the eggs, to determine which one is raw and which one is hard-boiled.
2. Have students spin the eggs at the same time and discuss their observations.
3. Have them spin the eggs again and use one finger to touch the top of each egg, causing a brief stop. (The cooked egg will stay still but the raw egg will start spinning again.)
4. Ask students to predict which egg was hard-boiled and which one was raw.
5. What would cause these results? (The insides of the egg have more inertia when they are liquid, like the raw egg, than when they are solid, like the hard-boiled egg. This slows the raw egg down so it stops spinning before the hard-boiled egg. However, when you stopped the eggs and then let go, the liquid in the raw egg was still moving. This movement, caused by inertia, started the egg spinning again.)

EXPLORE (Part 2)

1. Hold up a small rubber ball. Ask students if they can think of a way to make it move in a circle. Experiment with some of their ideas.
2. Have students place a ball in the bowl and take turns within their groups, rotating the bowl in a circular motion.
3. Repeat step 2 with the Ping Pong ball and other available balls.
4. Why is the ball rolling around the bowl? (Force is being applied to it and it wants to move in a straight line, but it can’t because of the rounded walls.)
5. Have students place the rubber ball on a desk and place the bowl over it.
6. Tell them they are going to spin the bowl upside down with the ball beneath it. Have them think about what will happen before they try it.
7. They should move the bowl in fast circular motions, making sure they hear the ball moving around the edge of the bowl.
8. Now have students lift the bowl and observe the ball’s path. (It will move across the table in a straight line until it hits another object, which stops it, slows it down, speeds it up, or changes its direction.)

**EXPLAIN**

Explain how the ball moved when you lifted the bowl and why that happened. (The ball moved in circles under the bowl as it spun, because its inertia was balanced by an inward force—the push of the curved walls of the bowl. This force is known as centripetal force. When the bowl was lifted, the centripetal force was ceased and inertia kept the ball going in its preferred straight line.)

**EXTEND/APPLY**

1. Play a game to help students visualize motion, including the direction and the changes in direction of moving objects.
   - Draw a horizontal line on the chalkboard. Ask the class to think of some object that moves along a path like this (e.g., a marble rolling across a smooth floor).
   - Draw a vertical line on the chalkboard. Ask what object might move along a path like this (e.g., a ball falling freely).
   - Draw a diagonal line on the chalkboard. Ask what object might move along a path like this (e.g., a plane landing).
2. When you feel the students have the idea, draw other “paths of motion” and see who can name them. Some examples may be:
   - handle of pencil sharpener as a pencil is sharpened
   - pitched baseball
   - rabbit hopping
   - ball bouncing on the floor or down a flight of stairs
   - pendulum
   - pebble skipping across a pond
   - reflector on the pedal of a moving bike
   - skateboarder going down a ramp and then up a ramp
   - pebble stuck on a moving auto tire (test by strapping chalk to the can and then rolling it on the chalkboard)
3. Encourage students to design their own paths of motion and have the class try to guess what made the paths, or give students the paths you want them to draw on the board and see if they can design the path so the class can figure out what path they were assigned (similar to charades).
ASSESSMENT

Read the following scenario to the class and then have them respond:
A boulder on top of a hill begins rolling down the hill when a boy pushes it. Once it starts down the hill, it continues to gain speed because of the force of gravity acting on it. Suddenly a new force acts on the boulder.
- Tell what this new force might have been. (Accept any reasonable answer.)
  Tell how this new force could change the motion of the boulder (e.g., change its direction, slow it down, speed it up, stop it).
APPENDIX J

HIDE AND SEEK ENERGY

BENCHMARKS and TASKS

SC.B.1.2.4 The student knows the many ways in which energy can be transformed from one type to another.

SC.C.1.2.1 The student understands that the motion of an object can be described and measured.

- The student identifies force as any push or pull (e.g., gravity, electricity and magnetism) that causes objects to change their state of motion. The greater the force is, the greater the change in motion.
- The student traces the flow of energy as it is converted from one form to another (e.g., potential to kinetic) through a system.

KEY QUESTION

Does a ball dropped from knee-height have the same amount of energy as a ball dropped from above the head?

BACKGROUND INFORMATION

Mechanical energy is the energy an object has because of its motion or position. There are two kinds of mechanical energy-kinetic and potential. Potential energy is energy an object has because of its position or shape. As you hold each ball, it has stored, or gravitational potential energy. The higher the ball is held, the greater the amount of potential energy. When you drop each ball, the potential energy is transformed to kinetic energy, the energy an object has because it is moving. The greater the speed and the mass of an object, the greater its kinetic energy is.

MATERIALS

Per group

1 large pan half-filled with wet sand
4 tennis balls – same size, same mass
1 metric measuring tape
1 balance and mass set

Per student

science journal
TEACHING TIP

Take the students outside for this activity.

ENGAGE

Predict whether a ball dropped from a lower height will make a dent smaller than, equal to, or bigger than the dent made by a ball dropped from a greater height. Chart predictions on the board.

EXPLORE

1. Have students find the mass of the tennis balls. (They should be approximately the same.)
2. Model how students should carry-out the activity.
3. Ask one student in each group to stand by the pan of sand and hold one of the tennis balls at knee-height over the sand. Tell the students to let the ball drop.
4. Students in the group should closely observe the dent the ball made in the sand.
5. Next, have the same student stand by the pan of sand and hold the second tennis ball at knee-height over the sand.
6. All students in the group should observe the dents the two balls made in the sand.
7. Students should use a metric measuring tape to measure and compare the depth and circumference of the two dents in centimeters. Record this data in the science journal.
8. Next, have students repeat these steps but this time, the balls should be dropped from a height above the head. (Note: Students should use fresh balls, since the first two balls will likely be covered in sand.)
9. Again, all students in the group should observe the dents the balls made in the sand.
10. Students should use a metric measuring tape to measure and compare the depth and circumference of the two dents in centimeters. Record this data in the science journal. Students should compare the two sets of data and determine the answer to the Key Question: Does a ball dropped from knee-height have the same amount of energy as a ball dropped from above the head?
11. Have students smooth out the sand and try the investigation again by dropping the balls from two different heights.

EXPLAIN

1. Which ball had more energy as it hit the sand? (The ball dropped from above the head.)
2. How can you tell that it had more energy? (The dent in the sand was bigger.)
3. Why do you think the ball dropped from overhead had more energy? (It had more gravitational potential energy since it was held up at a higher position.)
4. When did potential energy transform to kinetic energy? (When the ball was poised overhead, it had gravitational potential energy, or stored energy. When the ball was released and started to fall, potential energy was converted to kinetic energy, energy of motion.)

5. Force is any push or pull that causes objects to change their state of motion. What force acted on the balls? (gravity)

EXTEND/APPLY

1. Have students brainstorm a list of follow-up questions to investigate: Would the results be the same if you dropped a different kind of ball? What would happen if you dropped balls with different masses from the same height?

2. Have each group choose one of the questions and carry out another investigation.
APPENDIX K

BOUNCING BALLS

SC.B.1.2.4 The student knows the many ways in which energy can be transformed from one type to another.

SC.C.1.2.1 The student understands that the motion of an object can be described and measured.

SC.C.2.2.2 The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

SC.C.2.2.4 The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object.
  - The student identifies force as any push or pull (e.g., gravity, electricity, and magnetism) that causes objects to change their state of motion. The greater the force is, the greater the change in motion.
  - The student describes the motion of an object by its position, direction, and speed.
  - The student uses scientific tools (e.g., stopwatch, meter stick) to measure the speed and distance traveled by an object and displays the data in a graphic representation.
  - The student traces the flow of energy as it is converted from one form to another (e.g., potential to kinetic) through a system.
  - The student demonstrates how inertia (an object’s tendency to resist a change in motion), gravity, friction, and mass affect motion.

KEY QUESTION

What will happen if the same ball is dropped from the same height onto the same surface over and over again?
BACKGROUND INFORMATION

Sir Isaac Newton discovered basic laws about how things move. His first law of motion states that objects at rest remain at rest and objects in motion remain in motion unless acted upon by an external force—a push or pull—that sets them in motion. Gravity is a force that’s always pulling things down toward the center of the planet. A tablecloth can be pulled out from underneath a set of dishes, if it is pulled quickly. This is because the dishes have inertia, a tendency to remain at rest. A bowling ball, once in motion, will continue in a straight line forever, unless it hits the pins, or friction eventually supplies the force to slow it down.

In this activity, a force, gravity, acts upon the ball to pull it down when it is dropped. The force of the surface acts upon the ball to push it back up. The ball changes direction (acceleration). However, the ball does not bounce back to its original height because some energy is absorbed by the surface on which it was dropped. Some of the energy is changed into heat energy in the collision.

As you hold each ball, it has stored, or gravitational potential energy. The higher the ball is held, the greater the amount of potential energy. When you drop the ball, the potential energy is transformed to kinetic energy, energy of motion.

MATERIALS

Per group of 3
- crayons
- Bouncing Balls! activity sheet
- tape
- 1 tennis ball
- variety of other balls (e.g., Ping-Pong ball, rubber ball)

Teacher
- 1 kick ball
- 1 long sheet of white paper
- tape

TEACHING TIP

Measurement is never exact. A measurement can always be taken to another, more precise decimal place. Measuring a ball in motion is even more difficult. Students should realize that their measurements are only approximations.

ENGAGE

1. Place a kick ball on your desk and wait for it to move under its own power. Ask the students, Will the ball move on its own? (No way! A body at rests stays at rest unless acted upon by some force.)
2. Stand beside a wall on which you’ve taped a long strip of paper. Drop the kick ball from chest height while a student marks the height to which the bottom of the ball bounces. Ask students to predict what will happen when you drop the ball again from the same height. Record their predictions and
tell them you will return to this after they have had the opportunity to explore this idea.

EXPLORE

1. Explain that students will measure the bounciness of balls by comparing how high each ball bounces. Divide the class into groups of three and distribute the materials.
2. Tape the activity sheet to the wall or to a heavy book so that the sheet stands on a flat surface such as a desktop or floor.
3. Have each of the three group members take turns dropping a tennis ball from the top number (1.0) on Part 1 of the activity sheet onto the surface in front of it while another student watches the numbers and points to the spot to which the bottom of the ball bounced.
4. Tell ball-droppers to mark the activity sheet to show how high the ball bounced.
5. Repeat dropping the tennis ball two more times. Remind each student to mark how high the tennis ball bounced each time.
6. Average the three heights to which the tennis ball bounced. Color the bar graph on Part 2 of the sheet for ball 1, the tennis ball.
7. Let students experiment with three other kinds of balls. Record three tries for each type of ball.
8. Have students label the charts with the type of ball they are using and make a mark to show the level to which the ball bounced each time.
9. Students should color the bar graph in Part 2 to show the data collected for the three other types of balls.

EXPLAIN

1. What does your data show? (The same ball dropped from the same height onto the same surface always bounces up to about the same point. Gravity acts on the ball the same way each time.)
2. How high did the tennis ball bounce each time? Why do you think so?
3. Did all of the balls react in the same way?
4. What makes the ball bounce? (Gravity pulls the ball straight down when it is dropped. When the ball hits the hard surface [an outside force] it changes direction and is pushed back into the air. An object at rest will remain at rest, and an object in motion will continue moving in a straight line at a constant speed until an outside force acts on it.)
5. What is this tendency for an object to resist a change in motion called? (inertia)
6. When did potential energy transform to kinetic energy? (When the balls were held above the table, they had gravitational potential energy. When the balls were released, the potential energy transformed to kinetic energy.)
EXTEND/APPLY

1. Return to the Engage activity. Ask student to look at their earlier predictions and ask if they would like to change them based on what they have learned.
2. Drop the kick ball two more times from the same height and each time have a student mark the bounce height on the paper. Students should be able to see that the same ball dropped from the same height onto the same surface always bounces up to about the same point.
APPENDIX L

ROCKET BALLOONS

BENCHMARKS and TASKS

SC.B.1.2.1 The student knows how to trace the flow of energy in a system (e.g., as in an ecosystem).

SC.B.1.2.2 The student recognizes various forms of energy (e.g., heat, light and electricity).

SC.B.1.2.4 The student knows the many ways in which energy can be transformed from one type to another.

- The student defines energy as the ability to do work or exert a force and recognizes that work is done every time a force is used to move something.
- The student describes energy as stored energy (potential) or energy of motion (kinetic).
- The student recognizes that energy comes in many different forms: (e.g., mechanical, energy of position and motion; electrical, energy of moving electrons; chemical, energy stored in chemical bonds; thermal, heat energy - the energy of moving and vibrating molecules; nuclear, energy contained in the nuclei of atoms; and radiant, energy that travels in waves like sunlight).
- The student discovers through experiences ways that energy can be transformed from one form to another (e.g., electricity to light, light to heat, potential to kinetic).

KEY QUESTION

What happens to an inflated rocket balloon when the air is released?
BACKGROUND INFORMATION

There are two kinds of mechanical energy – kinetic and potential. Potential energy is energy an object has because of its position or shape. Kinetic energy is the energy an object has because it is moving. The greater the speed and the mass of an object, the greater its kinetic energy. When the rocket balloon has been inflated and the neck is being pinched closed, the balloon has potential energy (stored energy). When the rocket balloon is released and moves along the track, the potential energy is transformed to kinetic energy (energy of motion).

Newton’s three laws of motion can be used to explain the movement of all objects in the universe. Newton’s Third Law states, “For every action, there is an equal but opposite reaction.” Newton’s Third Law says that when one object exerts a force on a second object, the second object exerts a force back that is equal in size but opposite in direction. All forces act in pairs. In this activity, when the air inside the balloon escapes, it pushes the balloon forward - an equal and opposite reaction.

MATERIALS

Per group

4 balloons of various sizes/shapes (Note: Every group must have the same set of 4 balloons.)
straws
cellophane or masking tape
1 metric measuring tape
10 m of fishing line or string coiled around an index card
Rocket Balloons data sheet

TEACHING TIPS

1. Assign launch teams before the lesson starts.
2. This activity should be done in a large, open area.
3. For each group, cut 10 m of fishing line and wrap it around an index card. Tape the line to the card.
4. This activity provides a perfect opportunity for supporting mathematics benchmarks/tasks in the measurement strand. As students are measuring the distance the balloons travel, insist they use metric measurement. If they record measurements in centimeters, reinforce how easily they can convert to meters since 100 cm = 1 m, they just need to move the decimal point (e.g., 367 cm or 3.67 m).
ENGAGE

1. Ask students how they would move a balloon from one end of the room to the other. Give balloons to several students and allow them to demonstrate their ideas.
2. Inflate a balloon and ask students to predict what will happen when you release it. Release it and observe.

EXPLORE

1. Ask a team of four student volunteers to help you demonstrate how to set up a rocket balloon track. Give one student the card of fishing line and have her slip a straw onto one end of the line. Extend the fishing line out and have a second student hold the opposite end of the line some distance away.
2. Have a third student select a balloon, blow it up, and pinch the end closed while the fourth student tapes the balloon to the straw. Be sure the balloon is taped to the straw and not to the line itself. (See the illustration below.)

![Diagram of a balloon track with a straw and balloon attached](image)

3. Have students predict how far they think the balloon will travel when released.
4. As the two students are holding the line taut and about shoulder height, the student who is pinching the balloon closed should release it.
5. Then one student should measure the distance the balloon traveled and record it on the data sheet.
6. Distribute materials to the teams. Challenge students to experiment with the four balloons of various shapes and sizes to see how far they can cause a balloon to travel along the track. (Some teams may need to lengthen their tracks!)

EXPLAIN

1. Allow teams to demonstrate their most successful launches for the class and to explain the conditions of the launch.
2. Discuss:
   What caused the rocket balloon to move along the tracks? (When the air inside the balloon escapes, it pushes the balloon forward - an equal and opposite reaction.)
   When did an energy transformation occur during the activity? (Potential energy changed to kinetic energy. At the instant the balloon was released, the potential
energy, energy stored while the balloon was pinched closed, changed to kinetic energy, energy of motion, which caused the balloon to move along the track.)

How did balloon size affect the flight? (The more air that was released, the greater the distance the balloon traveled.)

Which of the four balloons traveled the greatest distance? Why do you think so?
Which of the four balloons traveled the shortest distance? Why do you think so?
What other variables may have affected the distance the balloons traveled? (the way the balloon was attached to the straw, the tautness of the line)

3. Remind students that energy is the ability to do work or exert a force and work is done every time a force is used to move something. Ask: Was any work done? (The force of the air escaping from the balloon pushed the balloon along the track. The balloon moved, so work was done.)

EXTEND/APPLY

Have students think about how launching a rocket balloon is similar to popping a kernel of popcorn. (The small amount of water in the starch inside the hull turns to steam, which builds up pressure, and POP! If there is no lid, the popcorn will shoot into the air just as the balloon shoots along the track.)

EXTENSIONS

1. Have students predict what will happen if they place the balloon on the track vertically rather than horizontally. Try it and see what happens!
2. Encourage students to investigate with tracks at different angles. Encourage the use of a protractor to measure the angles of the tracks.

ASSESSMENT

Have students describe in their notebooks other examples of action and reaction forces.

Investigators: ROCKET BALLOONS

Experiment with a variety of balloon rockets. Measure the distance the balloon traveled. If applicable, write the distance traveled in at least two ways (e.g., 241 cm and 2.41 m).

<table>
<thead>
<tr>
<th>Balloon number</th>
<th>Distance traveled</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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</table>
Write your conclusions about the activity.
APPENDIX M

STUDENT SCIENCE NOTEBOOK SCRIPT

Today we are completing an inquiry called ____. The inquiry continues our study of force and motion. As we complete the inquiry you are expected to note your predictions, observations, and questions in your science notebook. All thoughts you write in your notebook are private and they should not be shared with your friends. After the inquiry is finished, you will have time to independently reread your notebook and make any changes by adding to or removing things you wrote.

After the inquiry is finished you will have three minutes to perform a Quick Write. The Quick Write portion of your science notebook is where you have time to write anything at all about today’s inquiry. You can write things you liked, things you did not like, things you learned, or things you wished you could do differently, just to name a few.

Your science notebook is a tool to show what you learned in today’s inquiry. You should take this part of the inquiry seriously and do your personal best.
## APPENDIX N

### ALIGNMENT OF RESEARCH QUESTIONS

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Research Question #1: Oral discourse</th>
<th>Research Question #2: Written Discourse</th>
<th>Research Question #3: Oral &amp; Written connections</th>
<th>Research Question #4: Gender</th>
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</thead>
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<tr>
<td><strong>Student Interview Protocol</strong></td>
<td>1. Does talking with your classmates help you learn science?</td>
<td>7. When did you use your science notebook in today’s lesson? (before, during, after inquiry)</td>
<td>1. Does talking with your classmates help you learn science?</td>
<td>1. Does talking with your classmates help you learn science?</td>
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<td>2. Did your classmates listen to your ideas?</td>
<td>8. How did writing in the science notebook help you understand today’s lesson?</td>
<td>7. When did you use your science notebook in today’s lesson? (before, during, after inquiry)</td>
<td>2. Did your classmates listen to your ideas?</td>
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<td>3. Did everyone in the group get a chance to speak?</td>
<td>9. Which type of entry in your notebook, the Quick Write, or the fill in sections was most helpful to you? Why?</td>
<td>8. How did writing in the science notebook help you understand today’s lesson?</td>
<td>3. Did everyone in the group get a chance to speak?</td>
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<td>4. How well did the group work together today?</td>
<td>10. Tell me what you learned today.</td>
<td>9. Which type of entry in your notebook, the Quick Write, or the fill in sections was most helpful to you? Why?</td>
<td>4. How well did the group work together today?</td>
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<td>5. Was there arguing in the group?</td>
<td>10. Tell me what you learned today.</td>
<td>10. Tell me what you learned today.</td>
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<td>6. If you had a choice, would you work with this group again? Why?</td>
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<td>10. Tell me what you learned today.</td>
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**Observation Guide**  
1. Exchange of information  
5. Use of Notebooks  
1. Exchange of information  
1. Exchange of information
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<th>Research Question #3: Oral &amp; Written connections</th>
<th>Research Question #4: Gender</th>
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Documents | Student science notebook | Student science notebook | Student science notebook | Student science notebook |
Documents | Group Transcript | Group Transcript | Group Transcript | Group Transcript |
APPENDIX O

SMALL GROUP OBSERVATION PROTOCOL

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<tr>
<th>Location:</th>
<th>Date:</th>
<th>Observer: M. Parks</th>
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<td>Starting Time:</td>
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Number of students in group: __b ___ g  Inquiry #: ____  Date: _____

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<th>Boy</th>
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1. Elaborate discussion
   - Question
   - Predict
   - Explain
   - Justify

2. Group status
   - Directive statement (command)
   - Acquiesce statement
   - Clarification
   - Ignore
   - Arguments
   - Bossy behavior
   - Interruptions

3. Prosocial behavior
   - Assurance/support
   - Cooperation
   - Encouragement
   - Argument/challenge

4. Use of notebooks
   - During inquiry
   - After inquiry
   - Independently
   - Peer input
APPENDIX P

STUDENT INTERVIEW PROTOCOL

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<th>Name of Interviewee:</th>
<th>Date:</th>
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<tr>
<td>Starting Time:</td>
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Introduction: Thank you for participating in my study on science talk and writing in elementary school. The purpose of this interview is to learn how talk between group members influences science learning. Pseudonyms, fake names, are used so your words are confidential, just between us. During the interview, I will ask you questions about today’s science inquiry. There are no wrong answers; I just want to learn about your thoughts and experiences working in today’s group. There are no grades given your interview answers. This interview should last approximately ten minutes. Can I have your permission to audio tape this interview?

Questions for Elementary Students

1. Does talking with your classmates help you understand today’s lesson? How?
2. Did your classmates listen to your ideas in the group?
3. Did everyone in the group get a chance to speak?
   a. Did anyone talk over anyone else?
4. How well did the group work together today?
   a. Explain why you said that.
5. Was there arguing in the group?
   a. Tell me about the argument.
6. If you had a choice, would you work with this group again? Why?
7. When did you use your science notebook in today’s lesson? (before, during, after inquiry)
8. How did writing in the science notebook help you understand today’s lesson?
9. Which type of entry in your notebook, the Quick Write, or the fill in sections was most helpful to you? Why?
10. Tell me what you learned today.

Conclusion: Thank you for your time and help with my study. Remember that this was confidential. If I have other questions, can I talk with you again?
APPENDIX Q

SCIENCE NOTEBOOK TEMPLATE

Inquiry Title________________________________ Date ____________

Focus Question: _____________________________________________

Prediction: ________________________________________________

..................................................................................

..................................................................................

Quick Write:

Data:
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<th>Claims (I think . . .)</th>
<th>Evidence (because . . .)</th>
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</thead>
</table>

Conclusions (I now know) & Reflections (I think/feel because):
APPENDIX R

SMALL GROUP TRANSCRIPT ANALYSIS

Number of students in group____: ____b ___ g Inquiry #____ Date_______

<table>
<thead>
<tr>
<th>Discourse</th>
<th>Girl #</th>
<th>Quote</th>
<th>Boy #</th>
<th>Quote</th>
<th>Researcher notes</th>
</tr>
</thead>
</table>

1. Elaborate discussion

   Question
   Predict
   Explain
   Justify

2. Group status

   Directive statement
   (command)
   Acquiesce statement
   Clarification
   Ignore
   Arguments
   Bossy behavior
   Interruptions

3. Prosocial behavior

   Assurance/support
   Cooperation
   Encouragement
   Argument/challenge

4. Use of notebooks

   During inquiry
   After inquiry
   Independently
   Peer input
REFERENCES


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