STRUCTURED INQUIRY LEARNING AND GENERATIVE DISCOURSE IN MIDDLE SCHOOL SCIENCE

by
Heather Littke

An Action Research Project Submitted to the Faculty of

The Evergreen State College

In Partial Fulfillment of the Requirements

for the Degree

Master in Teaching

2015

This Action Research Project for the Master in Teaching Degree

by

Heather Littke

has been approved for

The Evergreen State College

by

____

Michi Thacker, M.A., Member of the Faculty

ABSTRACT

The objective of this case study was to explore how structured-inquiry learning segments influence generative discourse among students in a traditional middle school physical science classroom. This case study took place in a suburban, medium sized city located in the Pacific Northwest. This action research project was embedded in a nine-week unit on force and motion. During this time, I developed three hands-on, Structured Inquiry investigations that were aligned using Newton's three Laws of Motion. The participants included 4 target students in a mixed seventh- and eighth-grade physical science class. Qualitative data were collected from video, exit tickets, and my personal field journal observations of student discourse. This study found that the hands-on portion of Structured Inquiry investigations created the most opportunity for generative discourse, but it was difficult for students to sustain generative discourse during certain sections of the learning segment. Also, there are many reasons that students fail to sustain generative discourse, some of which are influenced by teachers and others by students. The research question for this study was: What inspires generative discourse during structured-inquiry learning segments among students in a traditional middle school physical science classroom? More specifically, I wanted to uncover the common elements in learning segments that led to generative discourse.

Keywords: Structured Inquiry, Generative discourse

ACKNOWLEDGEMENTS

I would first like to thank my mother and father, Jennifer and Willis Littke, my sister, Kim Hanft and her beautiful growing family, and my wonderful, helpful and amazing fiancé, Andrew Claiborne. You all have helped me in so many ways and I cannot thank you enough for the support that you have given me. I would also like to thank my future in-laws who have been so very supportive during my graduate school experience. Of course, I have to thank my beautiful friends, who I know will never read this, but still stood by me and held my hand during this process.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

According to the Office of Superintendent of Public Instruction's (OSPI) *Washington State Report Card* (2014), 66% of 8th grade science students demonstrated proficiency on the Measurements of Student Progress Test (MSP), which was adopted in 2009 to measure student progress towards the Washington State K-12 Science Learning Standards. The 2013-2014 improvement plan for the focus school of my study was to increase this number to 74% for the 2014 MSP, which is consistent with district grade level goal matrix. In the push to adopt the Next Generation Science Standards (NGSS), Washington State is anticipating that the new standards will have an impact on the development of standardized tests such as the MSP (NGSS, 2013).

Due to the No Child Left Behind Act of 2001, teachers are feeling pressured to teach to the test. State-mandated testing is causing many teachers to embody the "banking concept", which stifles creative power by treating the student as a receptacle for information (Freire, 2000). This pressure has led to most middle school science classrooms taking on a more traditional approach using teacher-driven monologues, which reduce opportunities for students to actively engage in science (Sadler, 2006). John Dewey states,

> Science has been taught too much as an accumulation of ready-made material, with which students are to be made familiar, not enough as a method of thinking, an attitude of mind, after the pattern of which mental habits are to be transformed (1933).

Traditional methods of teaching science can be problematic for student learning. Often, the learning activities are not familiar to students and the knowledge is too abstract and out of context (McDonald & Abell, (2002). Traditional schooling methods often treat students like objects rather than human beings. In such a situation, the “solution is not to ‘integrate’ them [students] into the structure of oppression, but to transform that structure so that they can become beings for themselves” (Freire, 2000, p.74). In order to avoid the “banking concept” of teaching, Freire urges educators to liberate themselves by taking action to promote what he refers to as “problem-posing” education, which promotes critical thinking by acts of cognition and not solely the transferal of information. There is a need to redesign science education that is geared towards innovation, creativity, curiosity and growth.

The Solution: Inquiry Based Science

According to the National Research Council (NRC) (2000), there are three main uses of inquiry in the science classroom: scientific inquiry, inquiry learning, and inquiry teaching. The NRC also developed the National Science Education Standards (NSES) in 1996, which mentions that [scientific]

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known in light of experimental evidence: using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p. 23)

Chinn & Malhotra (2002) add that authentic scientific inquiry involves research that is carried out by the scientist and that schools need to approach inquiry in a more simple way by only capturing some of the key components of inquiry. The definition of inquiry can be complicated and misinterpreted because the term *inquiry* is used to describe both inquiry learning, inquiry teaching, and inquiry science, which makes the definition confusing to most teachers (Anderson, 2002; Colburn, 2000; Welch, et al., 1981). According to the NSES (1996), inquiry learning refers to a learning process that engages students. Inquiry teaching is harder to define but it is often seen as a more desired method of instruction (NSES, 1996). Colbern et al. (2010) describes inquiry science teaching as instruction that reflects what scientists do. Inquiry teaching allows students to use inquiry learning and do inquiry science, although the existing literature was inconsistent regarding exactly what inquiry teaching entails. LLewellyn (2013) adds that habits of mind are also important to inquiry teaching because they correspond with the values and beliefs of the teacher. However, these habits of mind fluctuate in meaning from different authors who have approached the topic of inquiry. They usually include: commitment, creativity, curiosity, reflection, innovation, fairness, thoughtfulness, integrity, sensitivity, openness, imagination, persistence, diligence, skepticism, flexibility and wonder (Llewellyn, 2013). These are important because the habits of mind of a teacher influences how a teacher approaches inquiry teaching in the classroom.

Due to Washington State's adoption of the NGSS in 2013, there is a need for transitioning from teacher-centered to student-centered classrooms. In conjunction with Washington State Science Standards, it will take about four years of full implementation of NGSS during the 2016-17 school year with NGSS aligned assessments beginning between 2017 and 2018 (Communications and Community Outreach, 2013). Currently we are in Phase 2 of the NGSS shifting process in Washington State, which is the classroom transitions, equity and practices phase (Washington State NGSS Transition Planning Document (2014). In this phase, science classrooms are in the process of transitioning to the new science standards. Which poses the question: What does a NGSS classroom look like? The NGSS science and engineering practice incorporates inquiry, which is one of the one of the Four Essential Academic Learning

Requirements for Washington State Science Learning Standards (NGSS, 2013). Inquiry teaching shifts the teacher's role from director to facilitator, which allows students to be more in control of their learning and supports students' ability to connect science to their real-world experience. Inquiry-based science puts students at the center of the classroom more than traditional methods that are dominated by lecture, direct instruction and textbook reiteration and recitation (Klahr & Nigam, 2004). A teacher from a NRC (2000) case study found that inquiry in the science classroom does not exist within the traditional method of science instruction. Instead, he found that the inquiry branches from the student's interactions with the lab materials as well as from student-student and student-teacher interactions. The aim of inquiry-based science is to develop students' critical reasoning skills and deepen their understanding of content knowledge (Windschitl et al. 2008). Thus is why it is so important to have teachers that understand how to implement inquiry in their classroom.

Inquiry-Based Methods

Before the implementation of the NGSS in 2009, Windschitl et al. (2007) conducted a study to improve the Washington State science standards and show that there are limitations to the effectiveness of some inquiry-based science methods. Their study speaks to the flexible nature of inquiry-based methods and that there is no one inquiry-based method that is going to work all the time and in every classroom. As such, they concluded that teachers must find a balance between different methods of inquiry-based instruction (Windschitl et al., 2007). Colburn (2000) believes that different inquiry-based methods should be used for different lessons and activities. His research splits inquiry-based science into four different methods: Structured Inquiry, Guided Inquiry, Open Inquiry, and the Learning Cycle. For the purpose of my research, I used Structured Inquiry as defined by Colburn (2000). Using a Structured Inquiry method, the teacher supplies the student with a hands-on problem in which students investigate using step-by-step procedures and materials. The teacher does not tell the students about the expected outcomes of the investigation and students are left to discover relationships between variables and to interpret their data on their own. Colburn states that Structured Inquiry investigations are comparable to so called cookbook activities, but tend to have less direction around what the students are supposed to observe and collect data on. This is why structured inquiry is a good transition in a classroom that is used to more organization and structure. Furthermore, to assist middle school students in any method of scientific inquiry, Colburn (2000) recommends teachers to provide:

- Activities that are concrete
- Concepts that are observable
- Activities that are centered around questions that the students can answer directly through investigation
- Using situations and materials with which students are familiar
- Choosing activities that are suited to the skill and knowledge level of students
- Activities that are not overly challenging or too easy.

Creating an Inquiry-Based Classroom: Collaboration and Discourse

Classrooms that take an inquiry-based approach create more interaction and collaboration between students (Lord, 1997). To create a more student-centered classroom, it is important to structure tasks that provide a collaborative learning environment. Vygotsky emphasized that interaction between students and collaboration with the teacher enhances the culture within the classroom by creating a cooperative learning environment (Cole, 1978). This gives the students time to build context, a common experience, and their thinking skills. In addition, it increases their comfort level and helps promote positive attitudes toward learning science (Amaral, 2002).

Furthermore, the most effective learning takes place when students are participating in an interactive classroom environment that employs an inquiry approach to curriculum (Wells & Arauz, 2006).

The NSES and NGSS emphasize that scientific inquiry is at the core of scientific literacy. Science curricula can be very challenging due to the dense academic language and is analogous to learning a foreign language. In order to promote the use of scientific language, Keys et al. (2000) suggest that there is an increase in the use of student-student and student-teacher dialogue within in the classroom. Likewise, Vygotsky believed that collaboration within the classroom helps students develop their understanding of the content and construct shared meanings through structured opportunities (Cole, 1978). Driver et al. (2000) states that scientific knowledge is socially constructed and that collaborative group work can be a tool to empower students through critically examining scientific claims. By creating a collaborative and active learning environment, student equity is cultivated, increasing and encouraging participation within the classroom (Gee, 2001).

Siry et al., (2012) uses the term *discourse* to refer to verbal and nonverbal communication that provides meaning making. Their research looks at how children learn science through social interactions and building and linking together students' prior knowledge. The social constructivist work of Vygotsky is central to the idea that social interactions lead to conceptual understanding. Educators and researchers have studied multiple characteristics of discourse between students, which include discourse that expresses conceptual understanding, types of discourse, teacher questioning, response strategies and scientific argument (McDonald & Abell, 2002). Collaboration in the classroom increases the dialogue between students and creates discourse communities, which help improve student contribution and engagement (Anderson, 2002, White et al., 1998). Discussion is fundamental to how students acquire knowledge (Wells & Arauz, 2006). When students work together, their communication builds upon each other's knowledge and can breed healthy relationships that facilitate intellectual and emotional growth. In one study, researchers applied Vygotsky's theories to promote an interactive and dialogic classroom (Lau et al., 2009). They found that by empowering and encouraging students to have open dialogue within the classroom, learning became a social process where students became co-verifiers, co-constructors, and co-investigators of their knowledge. Likewise, Wells & Arauz, (2006) found that inquiry-based instruction led to more student discourse and dialogue in the classroom. Their study also found that it was not necessarily how the dialogue of a group conversation is started, but how students interacted with each other. This is why looking at how students interact is crucial when designing inquiry-based group activities. Teachers can differentiate dialogic interactions between students by structuring group work that allows students to equally participate in collaborative work (McDonald & Abell, 2002).

Function of Language and Discourse in Inquiry Science

There is much research that has been done on the function of discourse, but few studies have gone into detail making the connection between inquiry science and discourse. In science education, discourse serves two functions: conveying and generating meaning (McDonald & Abell, 2002; Mortimer and Machado (2000). Similarly, Wertsch and Toma (1995) explain that there are two main functions of language in the classroom, univocal function of language and dialogic functions of language. The ideas around the function of language and discourse in these studies can be tied together. In dialogic function of language, discourse participants extend conversations by asking questions and responding and promoting thinking (Wertsch & Toma, 1995, Keys et al. 2000). The univocal function of language is used in the transmission or conveyance of information (Wertsch & Toma, 1995). McDonald & Abell, (2002) found that inquiry-based activities produce what Mortimer and Machado (2000) refer to as generative and authoritative discourse. McDonald & Abell, (2002) define generative discourse as meaning-making and authoritative discourse as dialogue that conveys meaning. Thus, generative discourse would be part of the dialogic function of language and authoritative discourse would be part of the univocal function of language. They also describe procedural discourse, which is used during a procedural role such as reading, gathering materials and recording information (McDonald & Abell, 2002). This would be observed as discourse that is often found in teacher lecture or when giving instruction.

McDonald & Abell, (2002) found that there were fewer learning opportunities during learning segments that were dominated by authoritative discourse. Groups were found to work best together when students were able to sustain their generative conversations and when lessons weren't dominated by procedural discourse. Similarly, Mortimer and Scott (2003) and Scott et al., (2006) looked at the differences between authoritative and dialogic discourse. Their study defines dialogic discourse as being open to multiple points of view. Likewise, Mortimer and Scott (2003) found that authoritative discourse did not promote collaboration or the exploration of each other's ideas. However, dialogic discourse allowed students to acknowledge the ideas of others.

Generative Discourse

By analyzing the classroom discourse of their focal students, McDonald & Abell (2002) determined that there were certain steps that lead to generative discourse. First, the generative conversation usually started with a student's observation or generative statement about an occurrence during a hands-on activity. After, the statement was validated or built upon, which in turn extended the generative discourse. Hadjioannou (2007) states that authentic discussions occur when participants use each other's ideas to construct their contributions to the conversation and that participants are presenting and considering multiple perspectives. The key to sustaining the discourse was through further extension of the conversation through additional student generative questions and statements.

Hands-On Inquiry

There are five types of reasoning tasks involved in scientific inquiry: hands-on inquiry, computer-simulated experiments, databases, evidence evaluation, and verbal design of studies (Chinn & Malhotra, 2002). Their study discusses how certain reasoning tasks are appropriate for true authentic inquiry. During scientific inquiry, students need a way to connect abstract concepts (McDonald & Abell 2002). Hands-on activities can be a tool to help connect students to these abstract concepts. Regarding scientific inquiry, the National Science Teacher's Association (NSTA) recommends that teachers assist students with designing and conducting hands-on investigations (NSTA 2010). These investigations should be used to collect scientific explanations to answer questions or hypotheses. Blackburn-Morrison (2005) found that there are strong relationships between hands-on learning and inquiry-based science methods. Inquiry-based, hands-on learning is beneficial to science classrooms because it increases the student's relationship with the content and brings students closer to science, often connecting science to their real world (Blackburn-Morrison, 2005; Chinn & Malhotra, 2002). Furthermore, hands-on activities can empower marginalized learners because they are interactive and do not require as much verbal instruction. In addition, hands-on activities can increase engagement in inquiry, help students construct shared meanings, and improve student understanding of science by decreasing the linguistic burdens that can be challenging for diverse learners (Bodzin et al. 2007, Lee, 2005). Many studies are looking at the benefits of hands-on inquiry based science activities that encourage students to pose questions and promote scientific argument (Baker et al., 2009; Driver et al., 2000; Sadler 2006).

Dilemmas with Inquiry-Based Science

Because this study was conducted in what is considered to be a traditional classroom, it was important to review the counterarguments for inquiry-based science. While some researchers (Kirschner et al., 2006, Klahr & Nigam, 2004) have debated whether traditional methods such as direct instruction are responsible for lower test scores, others have claimed that traditional methods are needed because of the way that standardized tests are structured (O'Reilly, 2007). Furthermore, Klahr & Nigam (2004) claim that more children learn from direct instruction than from discovery learning [inquiry learning]. Kirschner et al. (2006) believe that both traditional and inquiry-based methods are effective and that a balance is needed between the different approaches.

Unfortunately, some teachers are reporting the struggle to adopt inquiry-based approaches because of the difficult transition from the traditional classroom model (Colburn, 2000). Thus, time is needed for this transition (Colburn, 2000). Teachers also face internal dilemmas such as beliefs and values as well as external obstacles such as funding (Anderson, 2002). Another issue with the adoption of more authentic approaches is that some teachers believe that scientific inquiry instruction only works well with students that are high-ability. Also, some teachers don't feel adequately prepared to teach inquiry-based instruction because it is difficult to manage. They are used to teaching facts, find it hard to change their methods, and feel responsible for guiding students to the next level (Welch, et al., 1981). Furthermore, many studies have shown that inquiry isn't being used in classrooms because of confusion behind the meaning of inquiry

(Anderson, 2002; Colburn, 2000; Welch, et al., 1981). Additionally, there are limitations to inquiry. Colburn (2000) states that most research on inquiry-based methods shows practicing "inquiry" often requires students to produce hypothetical and deductive reasoning, which can be challenging to young students. His research also explains how abstract concepts are often difficult for concrete thinkers to develop. Because middle school students are often in a stage of concrete thinking, this is problematic. Science practices can be most challenging for students who aren't encouraged at home, have less experience in school science, and who can not relate science to their present or future experience (Lee, 2005). This is why it was important for me to look at how teachers are approaching science and the benefits of developing methods that are inquiry-based and hands-on.

Quality Indicators for Motivational Literature

The McDonald & Abell, (2002) study was the motivation for my research, so quality indicators were evaluated here for the credibility of the study. The overall credibility of the McDonald & Abell, (2002) study is considered moderate, only because researchers did not manipulate the research setting and the teacher designed the inquiry-based course for the students. The researchers observed two groups of elementary students and frequently met to discuss comparisons from the observers of the two groups, which strengthened the credibility. McDonald & Abell, (2002) validates the study data through triangulation of their field notes, journals, and interview answers. The dependability of the study is also moderate. The findings are consistent with data, and are consistent with a long-term study. Dependability could be strengthened with more detailed description about the participating students – age, gender, or relationships between participants. The transferability of the study is strong. This study could easily be transferred to other settings such as high school, middle school, or college. If this study were repeated in a similar setting, it would most likely yield similar results with variation in differences in student personalities and socialization. The confirmability of the study is solid because the data can be tracked back to the source. Also, confirmability is strengthened due to the naturalistic methodology of the study.

Research Plan and Research Question

The main goal of my research was to design hands-on Structured Inquiry-based activities using aspects of the NGSS framework for scientific inquiry to promote discourse within the classroom. To plan for these activities and enhance discussion within the classroom, I paid special attention to student discourse, in particular generative discourse that was produced during Structured Inquiry-based activities. For the purpose of my study, I use the term 'generative discourse' to describe Mortimer and Scott's dialogic discourse. Because the focus of my study was on generative discourse, I have defined it as *meaning-making discourse* (McDonald & Abell 2002) where students are respectful of each other's ideas, feel comfortable sharing, contributing, responding and extending or adding to the conversation by asking questions or hypothesizing, and proposing different perspectives to promote thinking (Wertsch and Toma, 1995, Keys et al. 2000, & Mortimer and Scott, 2003). The study objective was not to change the structure of the classroom, but to see the benefits of a more student-centered classroom by using inquiry-based methods of science. For my study, I structured groupwork in a way that allowed equitable participation for all group members. While designing group work, attention was paid to status issues by categorizing the high- and low-status students within the focal group prior to the learning segment. Participation in the classrooms is affected by the status of students, and students with higher-status may not acknowledge ideas from other students which limits the lower-status students' understanding of the content (Featherstone et al., 2011). My review of the literature has helped me develop a definition inquiry teaching since there is much confusion and misunderstanding around the subject. I have defined inquiry teaching in the science classroom as teaching that is student-centered (Colburn, 2000), involves hands-on (Anderson, 2002; Colburn, 2000; NSES, 1996), interactive and collaborative activities (White et al., 1998) that resemble actual science (Chinn & Malhotra, 2002; Colbern, 2010), produces discourse communities that help students make meaning of the content (McDonald & Abell, 2002, Lau et al., 2009, White et al., 1998) and provides content that is relevant to the student's real-world (Anderson, 2002; Lee, 2005; Zeidler et al. 2009). Further detail about my research plan is given in the Chapter 2 - Methods and Analysis section.

The literature review was an excellent way for me to identify and incorporate the appropriate theories to guide me through the case study design (Mertens, 2010). Through reviewing the literature, my current research focused on what it looks like to create an inquiry-based classroom that was collaborative and allows the students to be interactive and work together. From this, I developed the following research question: What inspires generative discourse during structured-inquiry learning segments among students in a traditional middle school physical science classroom? More specifically, what are the common elements in the learning segments that lead to generative discourse?

CHAPTER 2 – METHODS AND ANALYSIS

My research focus investigates the common elements of structured-inquiry learning segments that initiate generative discourse in middle school science. Through designing inquiry-based activities in a physical science class, my research has helped me understand more how inquiry-based teaching in science increases student collaboration and promotes generative discourse within the middle school classroom setting.

Research Background

This case study was part of an action research project that took place during the fall of 2014 throughout my first quarter of student teaching. My study was conducted during my first experience with a combined 7th and 8th grade physical science classroom. I am a 31 year old, White female pre-service teacher. By being aware of my positionality as a White female pre-service teacher in a diverse suburban school, I have become more conscious of how my lenses affect my assumptions, interactions and relationships with students. For this research I was mindful of the effects that dominant culture has on the power dynamics of the classroom. I am attentive and aware of my possible biases in analyzing the diverse learners in the classroom. Mertens (2010, pg. 252) suggests that White researchers in a diverse school should "build more inclusive ways to discover the multiple views of their participants and adopt more personal interactive roles with them". During the winter and spring of 2014, I had previously worked in a life-science classroom with the focus teacher during my practicum placement in my first year of my Masters in Teaching program. This previous placement allowed me to create relationships with the 7th grade students who would be returning as 8th graders during my research project. Consequently, I was able to develop closer relationships with the focal students prior to the study.

Participants and Settings

My case study took place in a middle school physical science classroom. The school was located in a suburban setting in a medium-sized city in the Pacific Northwest. The school was situated in a diverse socio-economic area with high military influence due to its close proximity to a military base. In the middle school there were a total of 549 students in seventh and eighth grade. The racial demographics of the school consist of 51% White, 15% two or more races, 14% Hispanic, 8% African American, 7.3% Asian/Pacific Islander, 6% Asian, 3% American Indian/Alaskan Native, and 2% Pacific Islander. The racial demographics of the classrooms typically consist of between 50-60% White, 10-15% two or more races, 10-15% Hispanic, 8-12% African American, 0-8% Asian/Pacific Islander, 5-8% Asian, 0-5% American Indian/Alaskan Native, and 0-5% Pacific Islander. Throughout the school, there was a definite range of socioeconomic status, and 46% of students receive free or reduced meals. 12% of the students receive Special Education and 3% of students were recorded as being transitional bilingual. Information was gathered from *Washington State Report Card* (2014) for the focus school.

This case study took place during a 3-week, 15-lesson inquiry-based unit on force and motion. In the unit the students explored multiple hands-on activities, including models and lab exercises. This study focused on 3 separate learning segments centered on Newton's Three Laws of Motion. Each learning segment lasted four days and included an introduction to the law (day 1), an investigation lab (day 2), analysis (day 3), and reflection and class discussion (day 4). The introduction lesson involved a lecture regarding the introduction and application of knowledge. The investigation labs involved the exploration, design, construction and analysis of the properties of force and motion. The analysis portion of the investigation was done on the third day and involved students analyzing their own data as well as a class analysis. The fourth day involved a self-reflection of the investigation and a class discussion of the patterns seen in the analysis. Through collaboration with my mentor teacher and the science department the curriculum was pre-planned for this unit.

The second period physical science class was used as the focus class for my case study. There were five periods of science per day in the focus school with this individual teacher and classes on average were around 50 minutes long. In the classroom, there were 15 male students, and 13 female students. There were typically between 25 and 28 students per class on a normal day. Within the class there were 12 seventh graders and 16 eighth graders.

This case study involved a class that was comprised of seventh- and eighth-grade students. Four focal group students were the center of my study, although this study was conducted on the whole classroom. This group helped me see the research in a focused way while still being representative of the whole class. Mertens (2010) states that the use of focal groups "allows the exhibition of a struggle for understanding of how others interpret key terms and their agreement or disagreements…They can provide evidence of ways that differences are resolved and consensus is built" (p.240). The focal students are representative of the whole group and include two female students and two male students. The students' ages are between 13 and 14 years old. The class has a variety of learners at different levels, including two students with Individual Education Plans (IEPs), five underperforming students or those with gaps in academic knowledge, one English Language Learner, two students with 504 plans and one "gifted" student.

Collaboration within the classroom helps students with structured opportunities to help develop their understanding of the content and construct shared meanings (Cole, 1978). For this study, it was important that the classroom was appropriately set up for collaborative group work. To assist with group work, the classroom setting consisted of eight tables that were set up for groups of four people. Group work was designed based on the Kagan Structures. This model provided student interaction that maximized communication, engagement, and collaboration (Kagan, 2009). In this model two girls and two boys were placed at each table. This structure also required specific roles for each student to assist in equitable work between group members. The activities in this study required active participation through specific roles for each student. The students alternated between roles for each investigation. The roles help students work together and addressed status issues in the classroom by creating an environment where students are held accountable to accomplish individually and as a group to complete a given task (Featherstone et al., 2011). For this study, I gave students interactive roles that were aligned with the tasks. The students were given the choice to choose their roles, but they had to do a different role for each investigation. To assist in the selection of group assignment, the students were also assessed on status.

For this study, I paid attention to status because participation in the classrooms can be affected by academic and social status (Featherstone et al., 2011). The focal group was chosen to have 1 girl and 1 boy of low-status and 1 female and 1 male of higher-status. The students with lower status typically did not participate during class discussion, while the higher status students tended to contribute to class on a regular basis.

The focal students were also analyzed prior to the study during multiple learning segments. For each focal student I created an individual case study that documented his or her basic information, status, discourse style, and observations about participation. Focal Students were analyzed on their discourse style based on Mercer's (1995) three types of talking and thinking which include disputational, cumulative, and exploratory, which are outlined below.

Mercers (1995) Three Ways of Talking and Thinking

1. Disputational talk: Short exchanges of disagreement or individualized decision making.
2. Cumulative talk: Discourse builds upon each other and is uncritical. Conversations are characterized by explanations, validations and sustained discourse.
3. Exploratory talk: Discourse builds upon each other and is critical. Conversations are engaged constructively with each other's ideas. The knowledge is shared publicly and their reasoning is more visible. (p.104)

To understand their discourse style prior to learning segments used in this study, I took notes of the focal students' discourse and participation in my personal field journal during group-work. Table 1 provides the focal student number, sex, age, observed status and prior discourse style.

Table 1

Discourse Style and Relevant Focal Student Information

Focal Student Number	Sex and Age	Status	Discourse Style
1	Female, 14	High	Exploratory talk
2	Male, 13	High	Cumulative talk
3	Male, 14	Low	Disputational talk
4	Female, 13	Low	Disputational and Cumulative talk

Note. Discourse style was noted prior to the study.

Research Design

My research design was loosely framed within the theories of Vygotsky. The social constructivist work of Vygotsky was centered on understanding of how social interactions lead to conceptual understanding. My study was focused on how students used those social interactions to construct conversations that are meaning-making. My research does not look deeply into how students internalize their social interactions, but rather, investigates the production of the generative discourse that plays a role in conceptual understanding. My research uses dialogic models of language suggested by Keys et al. (2000). Their research suggests that dialogic models of language are appropriate for conducting research on the practice of inquiry. This study uses the dialogic models of language framework because generative discourse is part of the dialogic function of language. Among the methodologies that are fitting for dialogic models of language framework, Keys et al. (2000) believe that the most fitting are case and naturalistic studies. With my research being situated in my fall student teaching placement, this study would be considered a case study because I had a major influence on the research setting. McDonald & Abell (2002) was a naturalistic study because it did not manipulate the research setting and only took on the observer position. By doing a case study, I am able to examine a single case attentively and in detail (Mertens 2010). I was fully interactive with participants of this study and was their full time student teacher for nine weeks. This study uses qualitative methods of data. Mertens (2010, pg. 265) states, "Qualitative methods allow a researcher to get a richer and more complex picture of the phenomenon under study than do quantitative methods".

Because the NSTA recommends that teachers assist students with designing and conducting hands-on investigations, I chose to use Structured Inquiry as defined by Colburn (2000) to design the group-work activities. The original plan was to use both structured and

Guided Inquiry and to see how each method enhanced discourse, but I found that Structured Inquiry-based activities were more realistic during my student teaching because students are not yet used to less structured activities. I chose Structured Inquiry because the controlled nature of this method was a good transition tool in a traditional classroom that is used to more structure and organization. To make the investigation a Structured Inquiry activity, I supplied the students with three hands-on investigations that explored Newton's Laws of Motion. To design the activities for this case study, I used the criteria described by Colburn (2000) for types of inquiry-based approaches and elements of the essential features and variations of scientific inquiry (NRC, 2000). The five essential features of classroom inquiry include:

1. Learner engages in scientifically oriented questions
2. Learner gives evidence priority in responding to questions
3. Learner formulates explanations from evidence
4. Learner connects explanations to scientific knowledge
5. Learner communicates and justifies explanations (p. 29)

For each of the five essential features there can be a lot of variation in the amount of guidance and structure within inquiry-based teaching (NSTA 2010). Table 2.2 describes these variations. I created activities that were concrete and straightforward. The investigations were a tool for me to connect students to abstract concepts such as force and motion. McDonald & Abell (2002, p. 5) believes that "learners need access to the world in order to connect the knowledge in their head with the knowledge in the world". To give this access, teachers need practices such as hand-on investigations. The concepts in the investigations were observable, and students not only designed the investigations, but they were able to observe the scientific phenomenon through carrying out multiple trials. I chose activities that were not overly challenging or too easy and were suited to the skill and knowledge level of the 7th and 8th grade students. By using the recommendations of Colburn (2000) with structured-inquiry learning segments, students in my study had more control of their learning.

Prior to the investigation, I demonstrated for the students what a procedure should look like. Students then created a step-by-step procedure for their investigation as a group. During the first investigation, I chose a group to share their procedure and attempted to follow their directions. This was done because about half of the class, primarily 7th graders, had never written a procedure and it was important for them to know how to correctly write a procedure so that they could follow it during their investigation. During Guided Inquiry, only the materials and problem are supplied by the teacher for the students to investigate (Colburn, 2000). The students are then left to devise their procedure to come up with a solution. Because I supplied the example of the procedure, the activities are considered Structured Inquiry.

Following the methods of Structured Inquiry, the students were supplied the materials for the investigation, which included a Designing an Investigation Worksheet (Appendix A). The worksheet for Learning Segment 2 and 3 used the same investigation format. The investigation format included an investigative question, variables, hypothesis, materials, procedure, data collection and analysis, data table, and conclusion. Because each worksheet followed the same format, the students became more familiar with each lesson. Prior to the lesson, students were exposed to the investigation format so that they could get used to the structure of designing an investigation. The students were accustomed with the materials and were given one day prior to the first investigation to explore and familiarize themselves with the materials. Each learning segment was centered on an investigative question that the students answered in their conclusion. Students were not told about the expected outcomes of any of the investigations and were left to discover relationships between variables on their own as well as to interpret their data in their conclusion.

Data Sources and Collection

My data sources consisted of qualitative data that was collected during the three-week unit. Mertens (2010, pg. 265) states "the most common methods of data collection associated with qualitative research include interviews, observations, and reviews of documents or other artifacts". This study was situated in a three-week unit that was centered in the middle of a nine-week unit on force and motion. The qualitative data sources were collected from video, exit tickets, and my personal field journal recording of student discourse. The data sources were triangulated which strengthens the credibility of my study (Mertens, 2010). The data that I collected helped me achieve a better understanding of how the learning segments enhanced student discourse. The video was the main source of physical evidence of student discourse, and allowed me to carefully analyze the dialogic interaction within the classroom during the investigation. Although, video was my main source of data, the exit tickets and the personal field journal have provided additional windows into the student's production of discourse. The exit tickets were another way to analyze written discourse and clarify the dialogic interactions within the classroom. This data source gives me a view through the students' perspective, whereas the video and the personal field journal are through my perspective. My personal field journal was used to reflect upon the structure of my lesson plans and what it was about the design of the learning segment that enhanced classroom discourse. The field notes also helped me take note of the 4 focal students interactions during a learning segment. Table 2 shows my data collection timeline.

Table 2

Data Collection Timeline

Learning Segment	Day 1. Introduction	Day 2. Investigation	Day 3. Analysis	Day 4. Reflection and Class Discussion
Week 1	Journal	Video Journal	Exit Ticket Journal	Journal
Week 2	Journal	Video Journal	Exit Ticket Journal	Journal
Week 3	Journal	Video Journal	Exit Ticket Journal	Journal

Note. Personal field journal is represented as “Journal”.

The exit tickets were collected from the whole class, although I analyzed the exit tickets received from the four focal group students. The exit tickets were focused on asking the students questions about their conversations that they had during the learning segment, with special attention being paid to the students’ generative discourse. After each of the three learning segments, students had ten minutes to fill out an exit ticket, which was designed to have students reflect on their interactions during the learning segment. Each exit ticket had one of the following inquiries:

- Explain in detail an instance in class today where you offered a different view or perspective to a conversation.
- What sort of questions did you ask your group members during the investigation and how did that help keep the conversation going?
- Explain in detail an instance where you replied to another student and added to a conversation.

- What was it about a conversation that you were having with another student that helped you come up with a new idea?

(See Exit Ticket Prompts and Alignment with Schedule in Appendix B.)

All three of the inquiry-based activities were videotaped. The activities were all introduced with a day of direct instruction, which was not videotaped. The main role of the videotapes was to look for when students use generative discourse during their investigation and during the class discussion. The videotapes helped me understand how the students were conceptualizing the activities and what inspired them to create dialogue. The videotaping assisted in catching and recording instances of student interaction, which cannot be done with the journals, or exit tickets. The videos also helped me analyze the types of generative conversations students were having with each other, such as when they are asking questions, hypothesizing, adding to a conversation or proposing a different perspective. The videos also helped me analyze the status dynamics in the classroom, which was important when observing the different types of discourse that students were using. Because the activities were designed to be student-centered, the students' conversations were more natural and their status more accurately reflects interactions with each other in the classroom. Certain sections of the videotapes (during the inquiry-based learning segment and the class discussion) were transcribed, coded and analyzed to look at different types of discourse. Only certain sections were analyzed due to the length of the investigations and to focus on parts of the learning segments where there was conversation.

During the 15 lessons, I took field notes on my observations of the students during class and during my observation of the videos. My notes consisted of my observations of the students' discourse during a learning segment and the effectiveness of Structured Inquiry-based activities on promoting discourse. In my notes, I paid special attention to what it was about the design of the learning segment that promoted discourse as well as the type of discourse that was stimulated during the students' conversations. The field notes helped me record my own observations of the students and assisted me in the documentation of what I saw and heard in class, as well as during the videotaping. My notes also included observations of student interactions, which allowed me to pay attention to my own discourse and what I did that assisted students to increase their dialogue in the classroom. The field notes also helped me reflect upon my internal transformation as I shifted my sociocultural lenses to encompass an inclusive, diverse, and culturally cognizant perspective. In my notes, I spoke to how my lenses affected my interactions with students and my ability to be responsive to the individual differences within my classroom.

This process of data collection aided my understanding and helped guide and improve my future practice. By creating a student-centered classroom that was inquiry-based, I learned more about what inquiry teaching looks like in a traditional middle school science classroom and what it was about the design of inquiry-based learning segments that stimulate generative discourse and promote the ability for students to talk science, as well as increase student participation and collaboration.

Data Analysis

This study used qualitative methods for data analysis. My main source of data was the videotaped learning segments. Short transcriptions were made from selected videotaped activities that demonstrate discourse between the 4 focal students. The categories for the coding were developed from the data as it was reviewed by creating a table of my observations. My personal field notes contain thick, rich description and provided much detail about my observations of student discourse. To identify patterns in the data, I used within case analyses methods (Mertens, 2010). The data was derived from transcribed videos, field notes and exit tickets. Each form of data was independently reviewed and compared for emerging patterns. I examined the data coded for frequency of behaviors and collected themes and discourse patterns in an interactive coding system. The transcribed videos were analyzed for reoccurring themes in generative discourse and were compared to field notes and exit tickets. The following themes were used to code for generative discourse.

- Sharing and contributing ideas
- Respectful of each other's ideas
- Responding and adding to the conversation
- Asking questions or hypothesizing
- Proposing different perspectives.

While further analyzing the student discourse, I used the following statements from McDonald & Abell (2002) to categorize what type of generative discourse had occurred:

- Generative conversations usually started with an observation or a generative statement of an occurrence during the investigation.
- Students would validate another group member's idea or observation.
- Students would propose ideas that would build upon a previous idea or extend the parameters of another idea.
- Generative questions are questions that were posed to share a personal idea or theory or that called for an interpretation or further explanation of a phenomenon that occurred.
- Generative conversations took place between focal students, when students asked generative questions or had a generative statement.
- Statements that were generative served the same function as a generative question.

- Continuous generative conversation took place when there was little sidetrack or distraction, where students immediately went back to talking about the science content.
- Continuous generative conversation took place when three or all of the group members took place in the discourse.
- Appropriation of others ideas is considered to be generative discourse. (p. 9)

Each of the above statements was given an acronym to use in coding the transcripts. Along with coding for generative discourse, I rated in my personal field notes the variation of inquiry during the conversation using the five essential features and variation of classroom inquiry adapted from NSES (2000) focusing on the amount of learner self-direction (Table 3). The type of discourse can determine the extent of inquiry that a classroom takes part in (NRC, 1996; 2000).

Table 3

Five Essential Features and Variations of Classroom Inquiry Compared to Amount of Learner Self-Direction

Essential Feature	Variations *More-------------Amount of learner self-direction-------------------Less* *4*	*3*	*2*	*1*
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in questions provided by teacher or other source
2. Learner gives evidence priority in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner Provided with evidence
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpened communication	Learner given steps and procedures for communication

Note. Adapted from Inquiry and the National Science Education Standards: A Guide for Teaching and Learning Inquiry and the NRC (2000) p. 29.

I focused on the amount of learner self-direction because the students were working in groups and I was only the facilitator for the lessons. Using table (3), I was able to develop connections between the five essential features of classroom inquiry and the production of generative discourse. For each conversation, I rated the variation of the inquiry in which the student was participating. The rating was derived from the amount of learner self-direction, four being the most amount of learner self-direction and one being the least. I looked at self-direction because inquiry teaching involves transitioning to a more student-centered classroom using inquiry-based methods of science. More student self-direction means that the students are communicating to each other and there is more potential for generative discourse.

Limitations

Using the Criteria for Judging Quality in Qualitative Research (Mertens, 2010), which includes: credibility, transferability, confirmability, and transformative criteria, I have critically analyzed the limitations of my study.

To strengthen the credibility of the study, I had prolonged and persistent engagement with the students. The study took place over three weeks in my 10-week fall student teaching placement, but I also had exposure to the 8th-grade students during my prior placement in the classroom. Because I had prior knowledge of the 8th-grade students that were be present in the classroom, but had no knowledge of the 7th graders in the classroom, this could also be seen as a limitation of my study. Prior experience with some students limits my ability to randomly choose a focal group. To counteract this, I chose to have a focal group that I had prior knowledge of so I could determine their discourse style. In my Master in Teaching Program we held peer-debriefing workshops and reviewed each other's papers. I also had multiple reviews from different faculty. The data was triangulated by comparing the 4 students' exit tickets, videotaped activities, and my personal field notes, which strengthen the credibility of the study (Mertens, 2010). The credibility of my study might have been strengthened with adding member checks. The credibility of my study may be weakened by subjectivity due to my positionality and biases.

The transferability of the study was strengthened by my detailed analysis and coding procedure. I supplied thick, rich description in my findings from my personal field journal, transcripts, and exit tickets. I maintained a study protocol that was detailed and recorded each step of my research process, which strengthens the dependability of the study. Each transcribed conversation was carefully analyzed and described in the findings. The transferability of my study was diminished by only using one four-person focal group and could have been strengthened if I was studying multiple groups in several classes. By using multiple cases, I could have strengthened my dependability.

To strengthen my confirmability, I checked my data throughout the study after each learning segment. After each learning segment I checked my data again and reviewed my previous data. The confirmability of the study was strengthened through making sure that all of the data can be tracked back to the source. My confirmability was threatened because I did not do a confirmability audit. The results of my study could be confirmed or validated by others through conducting a data audit of the data collection and procedures used for analysis. The confirmability may be threatened by my bias towards adopting an inquiry-based student-centered classroom although I attempted to limit my subjectivity for the sake of my study.

The transformative criteria for my study would be my attention to voice. By focusing on the discourse and status of the students, I was able to seek out students who were silent and tried to engage and involve those who are marginalized within the classroom. To strengthen my transformative criteria, this study proposed practices that increase and support learning for all students. To further strengthen the transformative nature of the study, I acknowledged my positionality and perquisites of privilege.

CHAPTER 3 – ACTION RESEARCH FINDINGS AND IMPLICATIONS

Description of Action Implemented and Response to Research Question

The focus of my research was to investigate how to create an inquiry-based classroom that was collaborative and which allows the students to be interactive and work together. From this, I developed the following research question: What inspires generative discourse during structured-inquiry learning segments among students in a traditional middle school physical science classroom? The research findings of my study are focused around uncovering the common elements in the learning segments that lead to generative discourse. I found two major findings: one focused around student opportunities for generative discourse during hands-on inquiry and the second focused on sustaining generative discourse during a learning segment. The findings that I would like to elaborate on for this chapter include:

1. Hands-on portions of the investigations created the most opportunity for generative discourse.
2. It was natural for students to have generative discourse during hands-on activities, but it was difficult for students to sustain generative discourse during sections of the activity that involved writing and collaborating with the group.

The evidence is presented through transcribed video conversations that took place over three learning segments. Each transcribed conversation is introduced within the context and short description of the lesson. After each transcribed conversation, I have included an analysis section about the themes that were derived from my analysis and synthesis of the data, how it provided support for my findings and what it helped me better understand. In the analysis, I used evidence from all three of my data sources -- video, personal research journal and exit tickets -- to triangulate and establish connections.

Generative Discourse During Hands-On Inquiry

My study results show that students had the most opportunity for generative discourse during the hands-on portion of the investigation. I attribute this increased engagement to:

- Fast-paced nature of the investigation
- Physical movement
- Student roles

During the actual investigation where students run three trials and have their hands physically touching the materials, the students were more engaged than during the writing portions of the investigation. My findings show that increased engagement led to more opportunity for students to have generative conversations. This shows that it can be natural for students to have generative discourse during hands-on activities, but it was difficult for students to sustain generative discourse during sections of the activity that involved writing and collaborating with the group. Students became more engaged as soon as they could set up the materials. As students set up the materials, they often would start to have generative conversations on how to properly set up the lab. I found that creating less structure for the investigation created more opportunities for student discourse. When I gave less structure for the lab, students were more apt to ask each other questions for interpretation or questions for further explanation. These questions would lead to students having sustained generative conversations. The evidence that I have provided for this section includes a transcribed portion of a video recording from Learning Segment Week 1, Lesson 2 and Learning Segment Week 2, Lesson 2. Both of these segments were done during the

Investigation Day. I chose these two pieces of evidence to show how hands-on investigations provide opportunity for students to have generative conversations.

Learning segment week 1, lesson 2: investigation.

During this lesson, the focal group was studying Newton's First Law of Motion: the Law of Inertia as well as investigating how mass affects speed. This lesson took place on the second day of Learning Segment 1, which was during the investigation. All members of the focal group were present for this lesson. This transcript was of the students working through their investigative trials. Prior to the investigation, students had a day where they explored the materials. The names of the focal students have been changed for the sake of this study.

> Marian: Ah! The cart is getting stuck right here.
>
> Dyzia: That is because the track is upside down.
>
> Marian: This part or this part?
>
> Teagan: The track that is attached to the ramp.
>
> Preston: Why does it matter?
>
> Dyzia: See, look at the track, the cart gets caught on the bump of the track where it sticks to the ramp.
>
> Preston: Oh. Got it.
>
> Marian: Okay, I am ready when you guys are
>
> Dyzia: I got the timer
>
> Preston: Are you holding the ramp so it doesn't move?
>
> Marian: Yup.
>
> Teagan: I am recording.

Teacher: Where is your group at?

Dyzia: We are just about to start Trial 1.

Teacher: Okay, I will leave you to it. What is Preston's job?

Preston: I am holding the track.

Teacher: The track is locked in, how about you hold the ramp, and Marian can focus on releasing the cart.

Preston: Okay.

Marian: Okay, I am ready to go. Are you ready? 1…2…3!

Dyzia: 100 seconds

Teagan: What! There is no way that was 100 seconds.

Dyzia: I mean centimeters, wait. I'm confused.

Marian: It is 100 centimeters in 1 second. The cart went 100 centimeters in 1 second.

Preston: Oh, I see.

Marian: Okay let's do it again. Trial 2. Ready?

Teagan: Right here? Oh wait, I see where to write it. Okay, I am ready.

Dyzia: 1…2…3! Go!

Preston: oh, the ramp moved, I saw it. We need to do that trial over again.

Marian: Woops, I forgot to hold it that time. Okay, lets do that again. 1…2….3!

Dyzia: 92 centimeters….per second.

Teagan: A little bit faster that time.

Preston: That was slower!

> Teagan: No, it was faster because the cart went 92 centimeters instead of 100…oh, I see. You are right. The first trial was faster.
>
> Marian: Shouldn't it be the same? We didn't change anything.
>
> Dyzia: That's why we are doing three trials. That's the variables, right? Something like that. We need to take the average of the 3 trials after we do trial 3.

The purpose for using this transcript was to look at how the hands-on portion of the investigations created the most opportunity for generative discourse. In this transcript, the students were working together during their investigation. At this point in the investigation, the students are running their first three trials and are filling out the data table for their Designing and Investigation Worksheet. The students were told to take a role during the investigation so that every person had a part in the investigation. During this investigation, Dyzia was the timer, Teagan was the recorder, Preston was holding the ramp and Marian was releasing the cart. This transcript provides an example of a generative conversation that occurred during the hands on investigation. This lesson helped me better understand what it was about the hands-on portion of the investigation that creates opportunity for students to have generative discourse. In this lesson, all four group members participated in the generative conversation. I saw that Preston was originally trying to sit back and not take part in his role until I came over and asked him what he was doing. Preston was a low-status student and I saw that he was trying to sit back during the investigation. During the hands-on investigation for this lesson, the lines between the students' status were blurred and low-status and high-status students had equal contribution. During this portion of the investigation, the group worked together to facilitate their role in investigation. Through watching the video and analyzing my notes, I saw that all group members were making an attempt to include each other in the conversation. This conversation contained mostly disputational and cumulative talk. There was no exploratory talk during this conversation and for the most part, the discourse builds upon each other and was uncritical. Overall, the group members were able to sustain their discourse, but due to the fast pace of this part of the investigation, they were unable to have a critical conversation about the meaning behind the investigation. During this conversation, Marian, Preston and Dyzia asked questions for further interpretation or explanation. These questions work as extenders for the generative conversation. When Dyzia says the results for trial one, Teagan's response was not necessarily respectful of Dyzia's idea but there was something about Dyzia's answer that didn't seem possible to Teagan. By Teagan reacting to Dyzia, it led to Marian and Preston contributing to the conversation. Marian responded with an explanatory answer by saying that the cart went 100 centimeters in 1 second. For this learning segment, Dyzia answered the exit ticket prompt A: "Explain in detail an instance in class today where you offered a different view or perspective to a conversation." in which she responded to this interaction although not actually attending to the prompt. In her exit ticket she wrote, "I contributed to the group when I said that the cart went 100 centimeters in one second. At first I did not say centimeters, but when Teagan corrected me it made more sense. This might of helped anyone else who didn't know…centimeters the cart went in a second". According to Dyzia, her contribution to the group, although not complete, was corrected by Teagan, which helped her understanding better and may have also helped others in the group.

Learning segment week 2, lesson 2: investigation.

During this lesson, the focal group was studying Newton's Second Law of Motion. In this lesson students were exploring this law through focusing on speed and collision. This lesson took place during the investigation on the second day of Learning Segment 2. All members of the focal group were present for this lesson. This transcript was of the students setting up their investigation. For this investigation, students were given less structure since the investigation was very similar to Learning Segment 1. The materials were the same, with the addition of a block and for this investigation, the students were releasing the cart at different notches on the ramp. The highest notch represented the fasted speed so the students do not need a stopwatch for this investigation. The students were also given a quick demonstration of setting up the investigation so that they were familiar with using the block.

Dyzia: We are missing the stopwatch.

Preston: Remember, we don't need a stopwatch for this one.

Teagan: Yeah, the speed is the notches.

Dyzia: I must have missed that. What?

Preston: See the notches on the top of the ramp?

Dyzia: Yeah, I see them but…

Preston: The top notch is the fastest speed. Here.

Marian: See it says it in the data table.

Dyzia: Oh duh. I get it. The lowest, um…notch is the slowest.

Teagan: There isn't enough momentum from that notch. I think.

Marian: There wouldn't be as much force. We haven't really learned about momentum have we?

Teagan: The A notch would have the most force.

Marian: I just kind of said that.

Dyzia: So what are we putting in the data table thing then? We aren't measuring speed.

Preston: Distance this block moves.

Teagan: This block will move when the cart hits it. See, the cart will bump the block and we measure how far the block moves.

Dyzia: How does this represent, what is it…um, Newton's 2nd Law?

Teagan: Force, Force equals mass times acceleration. The high notch would probably be the highest acceleration right? I think that is right.

Preston: Sounds right to me. For my hypothesis I wrote, If I release the cart at the A notch, then it will cause the block to move further, because the cart will have more force.

Dyzia: Oh. Okay. So that makes more sense to me now.

The purpose for using this transcript was to provide another example of how the hands-on portion of the investigations created the most opportunity for generative discourse. This transcript also provides evidence for my findings that during groupwork, certain types of generative discourse lead to other types of generative discourse. This evidence helped me better understand what it was about the hands-on portion of the investigation that creates opportunity for generative discourse. In this transcript, the students were working together and were about to start their investigation. During this transcription, the students discussed a few things about the investigation that were different than the prior investigation. As with Learning Segment 1, all four of the group members participated in the generative conversation during the hands-on portion of the investigation. Through careful analysis of the video and field notes, I saw that all four of the group members were making an attempt to participate in this conversation. This conversation contained exploratory talk. The discourse builds as each student participates in the conversation. The discourse was critical and the students get into some exploratory conversation around how the investigation relates to Newton's 2nd Law of Motion. When Dyzia asks how the investigation relates to Newton's 2nd Law of Motion, the conversation became more critical. This question extended the conversation because it asked for further explanation and interpretation. The group members were engaged in the conversation and were freely sharing their ideas and were validating each other's ideas.   Overall, the group members were able to sustain a generative conversation that was critical and collaborative. At the beginning, Dyzia thought that the group was missing the stopwatch, but Teagan replied with a correction because he knew that for this lab, they would not need a stopwatch. Marian, Preston and Teagan participate in explaining to Dyzia why they were using the notches for the speed of the cart. Teagan then adds to the conversation by saying that releasing the cart at the lowest notch wouldn't give the cart enough momentum. The other three group members were unfamiliar with the vocabulary "momentum" because we had not gone over it in class yet. This was why Marian adds in that there wouldn't be enough force. Teagan doesn't acknowledge Marian's contribution, but almost tries to claim it as his own idea and adds that the A notch would have the most force. Marian notices, that her ideas were not acknowledged and drops out of the conversation. Teagan wrote about this interaction in his exit ticket the next day when answering the prompt "What was it about a conversation that you were having with another student that helped you come up with a new idea?" Looking at my field notes, I had to clarify this prompt for Teagan because he was having a hard time remembering and also did not understand what the prompt was asking. My field notes say "Teagan was confused on the prompt so I told him to think about it in a different way. I asked him if there was anything that anyone said that made him come up with a new idea. He replied that the group got ideas from him and that he didn't remember. On the exit ticket Teagan wrote, "I remember I said momentum, and no one knew what I was talking about, but we watched that Bill Nye video on momentum so I knew what it was. It is just like saying the A notch had the most force so pretty much the same thing". Teagan's discourse style was Cumulative Talk, so he often provides validations and justifications during a conversation. When Teagan revoiced Marian's ideas but acknowledged them as his own, he was trying to justify his own use of the word "momentum" by saying "The A notch would have the most force". During the hands-on investigation, the lines between the students' status were blurred and low-status and high-status students had equal contribution until Teagan, who was high-status, didn't acknowledge the ideas of Marian. At this time in the investigation, Marian's low-status became more visually apparent and she began to check out of the conversation.

Sustained Generative Discourse

My study found that it was relatively easy for students to have generative discourse during hands on activities, but it was difficult for students to sustain their generative discourse. Through careful analysis of the video transcripts, exit tickets and field notes, I found that there were many different themes that arise in generative discourse during inquiry-based activities. Through combining the literature with the themes that were derived through a coding process, I condensed a list of five major generative discourse themes. Table 4 illustrates these five themes along with examples.

Table 4

Five Themes of Generative Discourse with Examples

1. Sharing and contributing ideas
    - Example: "I think we need to turn the track around so that the cart will not get stuck."
2. Respectful of each other's ideas
    - Example: "I see, the track was upside down, thank you for pointing that out."
3. Responding and adding to the conversation
    - Example: "Yes, the track was upside down, but it also needs to be locked into the ramp."
4. Asking questions or hypothesizing
    - Example: "If we add more weight, the cart will go faster, because the more weight will increase the speed of the cart down the ramp."
5. Proposing different perspectives
    - Example: "The weight could also cause the cart to slow down because there will be more weight pulling down the cart, which will cause friction with the track."

From these themes, I also developed a list of different types of reoccurring generative discourse combinations (GDC). GDC's are combinations of different types of generative discourse themes. See Table 5 Generative Discourse Themes, Codes and Examples of Generative Discourse Combinations (Appendix A). For this table, I took the themes and coded the transcribed videos, research journal, and the exit ticket for the different types of GDC's. For instance, a GDC would occur when a student shared their idea and then another student would respond to or add on to their idea. The more GDC's in a conversation, the more likely the conversation was to be considered sustained generative discourse and more likely amount of learner self-direction (more student centered) because the group was able to carry on their conversation with little teacher interruption. Table 5 also gives examples of how discourse themes can be structured during a conversation. There are probably an infinite amount of GDCs that could occur in a conversation. This table also shows how the combinations can lead to sustained generative conversation.

Groups were more likely to have generative discourse during any sort of collaborative work, although my study found that it was hard for students to have sustained generative conversations during their investigations. There are multiple reasons why students fail to sustain generative discourse. I have compiled these reasons into two categories, which include student-influence and teacher-influenced. Student-influenced actions that are from the students themselves and lack teacher involvement. Teacher-influenced actions are related to my involvement either orally or physically, such as with the design of the worksheets or through teacher interruption.

There were many student-influenced reasons that students fail to sustain generative discourse. These include:

- Lack of basic generative discourse (conversation starters)
- Lack of GDCs due to:
    - Procedural discourse
    - Lack of acknowledgement between students
    - Lack of participation
    - Changing the subject
    - Conversation became unnatural

These student-influenced reasons were often due to status-related issues in the group. When conversations became unnatural, they became both mechanical and forced. I attribute this to the influence of the videotaping on student interactions. The students, who were unfamiliar with the videotaping process may have felt pressure to communicate, which would have impacted their comfort level and affected their ability to have a continuous conversation.

I also found that there were also teacher-influenced reasons that students fail to sustain generative discourse. These mainly were related to teacher interruption in the design of the student work. Teacher interruption may seem like the most apparent teacher-influenced reason that students fail to sustain generative discourse, but it this also the most prevalent reason. Design of the student physical work also led to interruptions in generative discourse. Parts of the investigation that involved segments of writing, where students were working together but were writing something, such as their hypothesis or conclusion, often led to less conversation and long moments of silence in the group. I attribute this to students wanting to own their own ideas. Too much structure during the learning segment was also not conducive for sustained generative discourse because it led to more procedural conversation and less exploratory talk.

Learning segment week 1, lesson 2: investigation.

During this lesson, the focal group was studying Newton's First Law of Motion: the Law of Inertia as well as investigating how mass affects speed. This lesson took place on the second day of Learning Segment 1, which was during the investigation. All members of the focal group were present for this lesson. This transcript was of the students working through their investigation. At the beginning, they worked alone on their hypothesis writing although they were allowed to work together. They start to have a conversation as they check in with each other to compare their answers. The names of the focal students have been changed for the sake of this study.

> Teagan: What did you guys do for the variables?
>
> Dyzia: For manipulated, I put I am changing the speed of the cart using different notches
>
> Teagan: I am measuring the distance the block moves on the track
>
> Preston: For controlled variables, I said that I used the same cart
>
> Dyzia: I said that I am keeping the height of the ramp and the cart and the track the same
>
> Marian: I put the same things, like the cart is the same and the ramp is the same
>
> Dyzia: What did you all put for the hypothesis?
>
> Teagan: If I put more mass in the cart, then I think it will go faster, because the weight will make it go down the track faster because the weight will push it down the ramp faster.
>
> Dyzia: I said that if the cart has 2 mass in it, then the cart might go faster, because it's going down a ramp, not up, so therefore the mass makes the cart go faster.
>
> Marian: I don't know if this is right but I wrote, "if the amount of the weight is added the cart, then it will move down the ramp faster, because it will have a different amount of weight going down."
>
> Preston: You might have to add the amount of weight that you are adding to the cart – like how many masses are you adding?
>
> Marian: Two

> Preston: Right, so how about this "If we add two masses to the cart, then the cart will move down the ramp faster, because the mass will make the cart go faster.
>
> Dyzia: Sounds good, but I a going to change my hypothesis so we all have the same one.
>
> Teagan: Yeah that is similar to what I had but I said more. I think that is ok.
>
> Marian: Can I see your paper?
>
> Preston: You just have to add how many masses.
>
> Marian: So if I add two weights to the cart. Wait aren't we just adding one first?
>
> Dyzia: That doesn't matter. This is just your hypothesis. Okay let's move on, this is taking too long.

The purpose for using this transcript was to look at the patterns in generative discourse while students work together on their Designing and Investigation Worksheet prior to running their investigation. This transcript provides an example of a generative conversation that was cut short due to student-influenced actions. This lesson helped me better understand sustained generative conversations and how students in the focal group either contribute to or cease to sustain the conversation. In this lesson, Marian participated the least in the generative conversation. Through watching the video and analyzing my notes, I noticed that Marian's body language along with her verbal language, shows that she was not as engaged as the other three students. Marian seems to be unconfident in her input to the group which may have been due to her lower status in the classroom. Other members of the group were not making much attempt to include Marian in the conversation. When Marian finally does make an attempt to share her ideas by giving her hypothesis, she says first "I don't know if this is right but I wrote…" and then she gives her hypothesis. Preston then responds to her and suggests that Marian should add to her hypothesis a specific amount of weight. By doing this, Preston was extending the parameters of Marian's idea by proposing a different perspective. This led to a validation response from Marian and sustained the generative discourse.

For this learning segment Marian answered the exit ticket prompt "What was it about a conversation that you were having with another student that helped you come up with a new idea?" in which she wrote about how Preston helped her with her hypothesis. Marian wrote, "I was talking to Preston and he told me to write how much weight I was adding. I changed my hypothesis so it could be tested. The group wanted to move on, but I was still trying to figure out what to write. I think that is when I got behind". Looking at my field notes for this day I wrote, "Marian looks lost. She has two papers in front of her – possibly trying to catch up? Not all group is engaged in conversation".

The sustained generative discourse ended when Dyzia said "Okay let's move on, this is taking too long". By saying this, Dyzia was halting the generative conversation but she was also trying to keep the group on track. Dyzia, who is a high-status student, acted as a facilitator in the group for most of this lesson. High-status students participate significantly more than low-status students, and high-status students are more likely to assume the role of the facilitator (Cohen & Lotan, 1995). For the most part, Dyzia was able to keep the group moving forward and sustain a generative conversation, but the conversation ended when she decided it was time to move on. Prior to this lesson, I noted Dyzia's discourse style as Exploratory Talk. In this lesson, Dyzia shared her knowledge and reasoning publicly by building upon the group conversation. Although, Dyzia constructively kept the conversation going, she did not always acknowledge the ideas of everyone in the group or check to make sure that everyone was on the same page and ready to move on.

Learning segment week 2, lesson 2: procedure.

During this lesson, the focal group was studying Newton's Second Law of Motion. This lesson took place on the second day of the Learning Segment 2. In this lesson the focal students were working together on their procedure for their Designing and Investigation Worksheet prior to running their investigation. All members of the focal group were present for this lesson.

Teagan: Ok, so my procedure…um, I don't like my procedure (laughs).

Dyzia: What did you put for your procedure Marian?

Marian: I'm…

Dyzia: Teagan?

Teagan: Marian has my paper. I have all seven steps. Marian can you give her my paper?

Preston: But you might not have all the steps. Remember we had like ten for the last one and there were only 7 spots. I think it's a trick.

Dyzia: Ha! It's not a trick! Our procedures need detail because these like are our instructions or whatever. Sometimes we just need more instructions. Are you done yet? I will just read mine.

Marian: I am not done yet. The procedure is the steps you need to take.

Teagan: Okay. "Grab a ramp and meter stick and set up 131 centimeter along the track and mark a starting point for the cart.

Dyzia: What about gather materials first?

Preston: I wrote, gather materials and then made a list of the materials that we needed.

Teagan: Woops. I'll add that. So, next step, is to grab the timer and the cart. Set the cart at the A notch and let go and press the timer to start.

Preston: I had something similar. I am just going to leave it.

Dyzia: If you think Ms. Littke can follow your procedure then it's okay.

Teagan: Oh and you have to hit stop on the timer once it goes by 131.

Preston: Centimeters. Don't forget to write that.

Marian: Add centimeters?

Preston: The centimeters is the unit. We have to have units or it could be like 131 like cats or something.

Dyzia: Gross.

Teagan: Where was I.…record the time that it takes for the cart to go from the A notch to the marked spot on the track. Do this three times. Next add one mass…

Dyzia: Slow down dang!

Teagan: I thought you were done. You have something like that?

Preston: I do.

Dyzia: I wrote "run three times and then add another mass". I was just adding to it.

Teagan: So yeah that was pretty much the same. Then I just wrote "repeat the recording and steps 2-4, three times for three trials so you have accurate data."

The purpose for using this transcript was to look at how status within the focal group affects sustained generative discourse. This transcript provides an example of a mix between procedural and generative conversation. The procedural conversation took place when Teagan was listing off what he wrote for the procedure. At this time in the video, the other three group members heads were down and they were either copying Teagan's procedure or adding to their procedure, but they were not all participating in the conversation with Teagan. The procedural discourse brief and usually turned into generative discourse when another group member contributed an idea, had a question, or made a generative statement. In this transcript, the generative discourse was sustained between only three members of the group Teagan, Dyzia and Preston. This lesson helped me better understand the impact of status on sustained generative discourse. In this lesson, Marian again participated the least in the generative conversation. Through analysis in the video and field notes, I can see that Marian's body language again shows that she was not participating as much as the rest of the group. She was hunched over her worksheet with her pencil in hand. I interpret her body language to her possibly feeling isolated from the group, but it could be due to some outside influence. In this lesson, Teagan, Dyzia and Preston did not make much attempt to include Marian in the conversation and often did not acknowledge her, which could have been due to her body language. At the beginning of the transcript when Teagan asks Marian to give his paper to Dyzia, he took away her support. She was already behind in the work and was trying to catch up. This made her fall even more behind. Because she was rushing to copy down Teagan's procedure, she fell even more out of the conversation. She seems to just barely be able to follow along, but loses her ability to participate in the group discussion. Cohen & Lotan (1995) state that low-status students can still be active in a group conversation but are often less influential than higher status students. By saying something on occasion, Marian appears to be contributing, but her words are not valued, so she slips back out of the conversation. This lesson is an example of how low-status students often participated (using generative discourse), but their words were not always valued. The high-status student does not acknowledge the low-status student's input and either talks over the student or cuts the student off with their own generative discourse. In return, this action makes the low-status student less likely to contribute later on during the conversation.

Teagan took more of a leadership role in this lesson by reading aloud his procedure. Teagan was a high-status student and his discourse style was Cumulative Talk. Teagan's comments to group members were usually uncritical and contain explanations or validations although in this lesson Preston was using Cumulative Talk. For example, he gave an explanation when Preston said, "The centimeters is the unit. We have to have units or it could be like 131 like cats or something". Preston was previously noted as being low-status and having a Disputational Talk discourse style. Through my observations, I witnessed Preston having many short exchanges with group members that are often disagreements. In this lesson, Preston was regularly participating during groupwork and his conversation builds upon others ideas. This explanation was used for a validation question from Marian so it was used to transmit an answer and not generate further conversation. The change in Preston's demeanor during this lesson could be attributed to his interest in using the materials, some outside force other than school, or because he was becoming more familiar with the group setting. On day 3 of the learning segment, Preston answered the exit ticket prompt, "Explain in detail an instance where you replied to another student and added to a conversation." Preston replied saying that, "I can't remember who said but I told the group to use centimeters as a unit because I know that's important. If you don't give centimeters it could be anything, like cats or 131 pizzas. I added to the conversation by helping them [the group members] get it right". Because Preston knew that the group had to be specific about what the unit of measurement was, he was able to contribute to the conversation and feel good about his influence on the group. Preston's confidence in his answer boosted his own sense of status in the group during this interaction, making him feel more comfortable contributing to the group.

Conclusion of Findings

This study was done to investigate what inspires generative discourse during structured-inquiry learning segments among students in a traditional middle school physical science classroom. My research findings were focused around uncovering the common elements in the learning segments that lead to generative discourse. Throughout my analysis, I found that the hands-on portions of the investigations created the most opportunity for generative discourse. When students are involved in the part of the activity that was hands on, there was more opportunity for students to talk to each other and share their ideas. I attribute this to increased engagement because of the fast-paced nature of the investigation, the physical movement of the students and the student roles. During the hands-on investigation, the lines between the students' status were blurred and low-status and high-status students tended to have more equal contribution. Consistent with the findings of McDonald & Abell, (2002), I also found that it was natural for students to have generative discourse during hands-on activities, but it was difficult for students to sustain generative discourse during sections of the activity that involved writing and collaborating with the group. During the hands-on portion of the investigation, the students had more opportunity and were able to have more sustained generative conversations. I found that there were student-influenced and teacher-influenced reasons why students fail to sustain generative discourse.

Future Implementation of Practices

This action research project along with the aforementioned focal group and student teaching has provided me with a broader context of how structured inquiry-learning can be used as a transition from a more traditional classroom to a classroom that is inquiry-based. My study agreed with the findings of McDonald & Abell, (2002) who found that during an inquiry-based activity students used generative discourse but failed to sustain generative discourse. The findings of my study also agree with McDonald & Abell (2002) and Mortimer and Machado (2000) who found that students are more able to have sustained generative conversations when there is less procedural or authoritative discourse.

This action research project has broadened my understanding of how I can

- transition to student-centered inquiry-based classrooms
- implement inquiry-based groupwork activities
- design inquiry-based groupwork that:
    - promotes generative discourse
    - increases students' ability to sustain generative discourse

Learning more about how to more student-centered inquiry-based classrooms is useful in order to prepare for the transition to NGSS in the 2016-17 school year (Communications and Community Outreach, 2013), which will be helpful as I begin my teaching practice. This study improved my understanding of how to implement inquiry-based groupwork activities and what using Structured Inquiry looks like in a traditional classroom. I understand more how I can differentiate the dialogic interactions between students by structuring group work in a way that is conducive for equal participation and encourages generative discourse. This project has helped me learn how to design inquiry-based groupwork that encourages students to talk about science.

Through analysis or student dialogue, I have learned a lot about students' ability to sustain generative conversations about science and this could be applied to future studies that look deeper into how the elements of inquiry-based activities inspire and sustain generative discourse.

Emergent Questions and Areas for Future Action Research

Through the synthesis of my research findings and literature review, it is clear that more research needs to be done to look at strategies for students to sustain generative discourse. From my research I have developed a new research question to further inquiry: What are some practical implications for sustaining generative discourse during inquiry-based learning segments? There is a need to look into designing inquiry-based science groupwork that inspires generative discourse, are aligned with state standards, and can be altered to fit a pre-planned curriculum. More research should be done on looking at how generative discourse enhances students' conceptual understanding, such as the McDonald & Abell, (2002) study. The NGSS is requiring teachers to implement inquiry-based science in their classroom and through my review of the literature, there is potential for further research into what inquiry teaching looks like.

If I was to continue on with this study, I could have given the students the opportunity to have a discussion to share and discuss their ideas regarding the investigation. I would like to look more into how I can design inquiry-based groupwork that encourages students to talk about science. Through creating a collaborative learning environment, some studies have looked at how collaborative inquiry-based methods encourage students' ability to "talk science" (Jiménez-Aleixandre & Rodrígues, 1999; Windschitl, 2008). In the future, I would like to encourage students to have a discussion that encourage students to "talk science" using Rosebery & Warren's (2008) Science Talks. Deneroff et al. (2013) found that Rosebery & Warren's (2008) Science Talks were the most productive feature to assist pre-service teacher candidates in using scientific discussion within the physical science classroom. Science Talks allow teachers to teach science through creating conversation. Science Talks are a way for students to ask questions and discuss their ideas about science openly while respecting others' ideas (Rosebery & Warren, 2008). Science Talks are a way for each student to have a voice in the classroom because they allow students to think out loud and express their understanding in their own way. The following strategies are given by Rosebery & Warren to initiate Science Talks within the classroom:

- Engage your students in a common activity with a scientific phenomenon
- Initiate an open-ended discussion about the event with your students.
- Listen carefully to what your students say as they share their thoughts.
- Encourage your students to talk with one another, allowing them to use a range of language styles to communicate their ideas.
- Act as a facilitator, rather than as a teacher, of the conversation.
- Allow the conversation to develop and unfold with as little intervention on your part as possible.
- Assume that the students understand one another, even if you do not yet understand what is being said.
- Reflect on your students' ideas after the science talk has concluded.
- Consider meeting with other teachers to discuss the science talk and your reflections. (2008, p. 10-11)

To assist in student discussion after each investigation, I should have used criteria from Rosebery & Warren for producing Science Talks. With this method, students would have been more likely to produce generative discourse through sharing their ideas, asking each other questions and responding and adding to each other's conversations.

REFERENCES

Amaral, O., Garrison, L., & Klentschy, M. (2002). Helping English Learners Increase Achievement Through Inquiry-Based Science Instruction. *Bilingual Research Journal, 26*(2), 213-239.

Anderson, R. (2002). Reforming Science Teaching: What research says about inquiry. *Journal Of Science Teacher Education, 13*(1), 1-12.

Baker, D., Lewis, E., Uysal, S., Purzer, S., Lang, M., & Baker, P. (2011). Using the Communication in Science Inquiry Project professional development model to facilitate learning middle school genetics concepts. *Professional Development in Education, 37*(3), 453-468. Retrieved February 22, 2015.

Blackburn-Morrison, K. (2005). *Three case studies of three high school teachers definitions, beliefs and implementation practices of inquiry-based science method including barriers to and facilitators of successful implementation*. The University of North Carolina at Greensboro.

Bodzin, A., Waller, P., Santoro, L., & Kale, D. (2007). Investigating the Use of Inquiry & Web-Based Activities with Inclusive Biology Learners. *The American Biology Teacher, 69*(5), 273-279.

Chinn, C., & Malhotra, B. (2002). Epistemologically authentic reasoning in schools: A theoretical framework for evaluating inquiry tasks. *Science Education, 86*, 175-218.

Cohen, E. G., & Lotan, R. A. (1995). Producing equal-status interaction in the heterogeneous classroom. *American Educational Research Journal*, *32*(1), 99–120.

Colburn, A. (2000, January 1). An Inquiry Primer. *Science Scope 23.* 42-44.

Cole, M. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.

Communications and Community Outreach (2013). State of Washington Office of Superintendent of Public Instruction Retrieved July 28, 2014, from http://www.k12.wa.us/Communications/pressreleases2013/NewScienceStandards.aspx.

Dewey, J. (1933). *How we think, a restatement of the relation of reflective thinking to the educative process*. Boston: D.C. Heath.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*, 287-312.

Featherstone, H. (2011). *Smarter together!: Collaboration and equity in the elementary math classroom*. Reston, VA: National Council of Teachers of Mathematics.

Freire, P. (2000). From pedagogy of the oppressed. In A. Darder, M. P. Baltadano, & R. D. Torres (Eds.), *The critical pedagogy reader* (pp. 52–61). New York, N.Y.: Bloomsburg Publishing.

Gee, J. P. (May, 2001). Reading as Situated Language: A Sociocognitive Perspective. *Journal of Adolescent & Adult Literacy, 44(*8), 714-725.

Hadjioannou, X. (2007). Bringing the background to the foreground: What do classroom environments that support authentic discussions look like? *American Educational Research Journal*, *44*(2), 370–399.

Jiménez-Aleixandre, M.P., Rodrígues, A.B. (1999). “Doing the Lesson” or “Doing Science”: Argument in high school genetics. *Science Education, 84*(6), 756-759.

Kagan Structures: A Miracle of Active Engagement. (2009, January 1). Retrieved February 8, 2015, from http://www.kaganonline.com/free_articles/dr_spencer_kagan/281/Kagan-Structures-A-Miracle-of-Active-Engagement.

Keys, C., & Bryan, L. (2000). Co-constructing Inquiry-based Science With Teachers: Essential Research For Lasting Reform. *Journal of Research in Science Teaching, 38*(6), 631-645.

Klahr, D., & Nigam, M. (2004). The Equivalence Of Learning Paths In Early Science Instruction. Effects Of Direct Instruction And Discovery Learning. *Psychological Science, 15*(10), 661-667. Retrieved February 22, 2015.

Lau, P., Singh, P., & Hwa, T. (2009). Constructing mathematics in an interactive classroom context. *Educational Studies in Mathematics, 72*(3), 307-324.

Lee, O. (2005). Science Education With English Language Learners: Synthesis And Research Agenda. *Review of Educational Research, 75*(4), 491-530.

Llewellyn, D. (2013). *Teaching high school science through inquiry and argumentation* (2nd ed.). Thousand Oaks, CA: Corwin.

Lord, T. (1997). A comparison between traditional and constructivist teaching in college biology. *Innovative Higher Education, 21*(3), 197-216.

McDonald, J. T. & Abell, S. K. (2002). Proceedings from the annual meeting of the American educational research association. *Essential Elements of Inquiry-based Science and its Connection to Generative and Authoritative Student Discourse.* New Orleans, LA.

Mercer, N. (1995) The Guided Construction of Knowledge: Talk amongst teachers and learners. Clevedon: *Multilingual Matters*, 104.

Mertens, D.M. (2010). Research and Evaluation in Education and Psychology: Integrating diversity with quantitative, qualitative, and mixed methods (3rd ed.). Thousand Oaks, CA: SAGE Publications.

Mortimer, E., & Machado, A. (2000). Anomalies and conflicts in classroom discourse. *Science Education, 84*, 429-444.

Mortimer, E., & Scott, P. (2003). *Meaning making in secondary science classrooms*. Maiden-head, England: Open University Press.

National Research Council. (1996). *National science education standards*: Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the National Science Education Standards*: A Guide for Teaching and Learning. Washington, DC: National Academy Press.

Next Generation Science Standards (NGSS). (2013). Washington, DC: Achieve, Inc. Retrieved from http://www.nextgenscience.org/.

O'Reilly, T., & McNamara, D. (2007). The Impact Of Science Knowledge, Reading Skill, And Reading Strategy Knowledge On More Traditional "High-Stakes" Measures Of High School Students' Science Achievement. *American Educational Research Journal, 44*(1), 161-196.

Sadler, T. (2006). Promoting Discourse and Argumentation in Science Teacher Education. *Journal of Science Teacher Education, 17*, 323-346.

Scott, P., Mortimer, E., & Aguiar, O. (2006). The Tension Between Authoritative And Dialogic Discourse: A Fundamental Characteristic Of Meaning Making Interactions In High School Science Lessons. *Science Education, 90*, 605-631.

Siry, C., Ziegler, G., & Max, C. (2012). “Doing Science” Through Discourse-in-Interaction: Young children’s science investigations at the early childhood level. *Science Education, 96*, 311-336.

Washington State Next Generation Science Standards Transition Planning Document (2014). State of Washington Office of Superintendent of Public Instruction Retrieved March 09, 2015, from https://www.k12.wa.us/science/pubdocs/ElementsofNGSSTransitionPlan.pdf

Washington State Report Card. (2014). Olympia, WA: Office of the Superintendent of Public Instruction. Retrieved from http://reportcard.ospi.k12.wa.us/summary.aspx?groupLevel=District&schoolId=1&reportLevel=State&year=2013-14.

Welch, W., Klopfer, L., Aikenhead, G., & Robinson, J. (1981). The Role Of Inquiry In Science Education: Analysis And Recommendations. *Science Education, 65*, 33-50.

Wells, G., & Arauz, R. (2006). Dialogue In The Classroom. *Journal of the Learning Sciences, 15*(3), 379-428.

Wertsch, J. V., & Toma, C. (1995). Discourse and learning in the classroom: A sociocultural approach. In L. P. Steffe & J. Gale (Eds.), *Constructivism in education* (159-174). Hillsdale, NJ: Lawrence Erlbaum.

White, B., & Frederiksen, J. (1998). Inquiry, Modeling, And Metacognition: Making Science Accessible To All Students. *Cognition And Instruction, 16*(1), 3-118.

Windschitl, M., Dvornich, K., Ryken, A., Tudor, M., & Koehler, G. (2007). A Comparative Model of Field Investigations: Aligning School Science Inquiry with the Practices of Contemporary Science. *School Science and Mathematics, 107*(1), 382-390.

Windschitl, M. (2008). *Science as inquiry in the secondary setting*. Arlington, Va.: NSTA Press.

Zeidler, D.L, Sadler, T.D., Applebaum, S., Callahan, B.E. (2009). Advancing Reflectic Judgment through Socioscientific Issues. Journal of Research in Science Teaching, 46(1), 74-101.

APPENDIX A

Table 5

Generative Discourse Themes, Codes and Examples of Generative Discourse Combinations

Generative Discourse Themes	Generative Discourse Codes	Generative Discourse Combinations Examples
Generative statement	GS	GS→AE→P→SGC
Share or contribute idea or observation	SI SO	SI→RC→RI→SGC
Conversation starter	CS	CS→RI→P→ SGC
Respectful of others ideas	RI	RI→V→AE→SGC
Response to conversation	RC	RC→V→AE+AB→SGC
Add to conversation or extend parameters or building upon each other's ideas	AE AB	AE→P→CC→SGC AB→CC→SGC
Asking questions or hypothesizing o Generative question o Question to share personal idea o Question for interpretation/further explanation	GQ QP QE	GQ→CS→RC→SGC QP→SI or SO→V→SGC QE→V→CC→SGC
Proposing different perspectives	P	P→AE→CC→SGC
Validation	V	V→CC→SGC
Continuing the conversation	CC	CC→P→RI→SGC
Changing subject	ChS	ChS→RI→CC→SGC
Changing subject but continuing conversation	ChSC	ChSC→RI→P→CC→SGC

Note. The Generative Discourse Combinations (GDC) are only examples of how discourse themes can be structured. There are most likely an infinite amount of GDCs, this table shows how GDCs can lead to Sustained Generative Conversation (SGC)

APPENDIX B

Learning Segment 1: Designing an Investigation Worksheet

Name:____ Period:_____

Designing an Investigation

Exploring Newton's First Law of Motion

An object at rest will stay at rest and an object in motion will stay in motion unless acted on by an *unbalanced force.*

Investigative Question: How will adding **mass** to a cart affect the **speed** of the cart over the distance of one meter?

Variables:

- Manipulated Variable: ____________________________
- Responding Variable: _____________________________
- Controlled Variable(s): __________________________

Hypothesis:

If ____,

then ____,

because____.

Materials:

- Meter stick
- 1 cart
- Stopwatch
- 2 weights
- Ramp
- Data Table (labeled)

New Vocabulary:

Mass

Speed

Distance

Procedure

Data Collection

Analysis

Diagram

Procedure:

(what steps are you going to take)

1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

DATA COLLECTION and ANALYSIS:

Draw a diagram of what you are observing/measuring.

Data Table:

Manipulated Variable	Responding Variable			
	Trial 1	Trial 2	Trial 3	Averages
0 Mass				
1 Mass				
2 Mass				

*speed is measured in centimeter/second

Conclusion

Claim: Answer the investigation's question.	
Evidence: Explain highest and lowest average data.	
Reasoning: Explain how the evidence connects to your claim.	

Question: What did this investigation tell you about Newton's First Law of Motion? (answer on back)

Exit Ticket Prompts and Schedule

Exit Ticket Prompts

A. Explain in detail an instance in class today where you offered a different view or perspective to a conversation.

B. What sort of questions did you ask your group members during the investigation and how did that help keep the conversation going?

C. Explain in detail an instance where you replied to another student and added to a conversation.

D. What was it about a conversation that you were having with another student that helped you come up with a new idea?

Table 6

Exit Ticket Prompts Aligned with Data Collection Schedule

Learning Segment	Day 3. Analysis
Week 1	Focal Student 1: A Focal Student 2: B Focal Student 3: C Focal Student 4: D
Week 2	Focal Student 1: B Focal Student 2: C Focal Student 3: D Focal Student 4: A
Week 3	Focal Student 1: C Focal Student 2: D Focal Student 3: A Focal Student 4: B

Note. Exit tickets were given out on Analysis Day 3 during each of the three learning segments. The focal students were assigned the above exit ticket topics A-D.